October 28, 2024

Tallgrass High Plains Carbon Storage, LLC
Attn: Mr. Kyle Quackenbush
4200 West 115th Street
Leawood, KS 66211

***Sent Via Email: kyle.quackenbush@tallgrass.com***

RE: Tallgrass High Plains Carbon Storage, LLC, Eastern Wyoming Sequestration Hub
Underground Injection Control Class VI Permit to Construct 2023-041, Spirea I-1
Facility Number WYS-021-00155
Laramie County, Wyoming

Dear Mr. Quackenbush:

The Wyoming Department of Environmental Quality Water Quality Division (WDEQ/WQD), Underground Injection Control (UIC) Program received a permit application for the Spirea I-1 Class VI injection well, located in Laramie County, Wyoming, on December 21, 2023. WDEQ determined that the application was complete and presented a draft permit for public notice and comment on July 30, 2024. The public comment period concluded on October 1, 2024, and comments from one commenter was presented to WDEQ for review and consideration on the issuance of the UIC Class VI permit. In accordance with Water Quality Rules, Chapter 24, Section 27(g), the Water Quality Division Administrator responded to comments identifying any changes that had been made to the permit and the reasons for the changes and describing any technical or regulatory concern that is within the authority of the Department to regulate. Changes to the permit focused on areas requiring clarification of information that appeared vague or unclear, grammatical or typographical edits, and document formatting. No regulatory or technical concerns were identified.

On September 23, 2024, WDEQ approved surety bonds EACX4044425, and EACX4046730 in the total amount of $1,119,000 submitted by Tallgrass High Plains Carbon Storage, LLC; therefore, WDEQ hereby issues Tallgrass High Plains Carbon Storage, LLC a UIC Class VI Permit to Construct for the facility referenced above. A copy of the Final Class VI UIC Permit to Construct is available at https://deq.wyoming.gov/water-quality/groundwater/uic/class-vi/. This Permit to Construct solely authorizes construction and preinjection testing activities of the Class VI well Spirea I-1 and any associated monitoring wells as listed in the permit. Following construction and preinjection testing activities, Tallgrass High Plains Carbon Storage, LLC shall apply for a permit modification for authorization to inject and operate the Spirea I-1.

The Permit to Construct lists monitoring, recordkeeping, and reporting requirements in Section 9. Please be aware that the permittee must report any noncompliance which may endanger health or the environment within 24 hours from the time the operator becomes aware of the circumstances as required in Section 9(B) and Table 1 of the Permit to Construct. This includes any monitoring or other information indicating that any contamination may cause endangerment to an underground source of drinking water. All reports associated with this permit, including all monitoring and testing reports, shall be submitted electronically to the Electronic Documents Submittal tab located at the link identified above.

After you have had a chance to review the Permit to Construct, please contact me to set up a permit issuance meeting to discuss permit requirements and next steps. If you have any questions regarding the permit or monitoring requirements, please contact me at (307) 777-8275 or tyler.harris@wyo.gov.

Sincerely,



Tyler Harris, P.G.
Geology Supervisor – UIC Class VI Program
Water Quality Division
Wyoming Department of Environmental Quality

cc: Karin Quigley, Administrative Assistant to the DEQ Director, WDEQ
Alan Edwards, Deputy Director, WDEQ
Jennifer Zygmunt, WQD Administrator, WDEQ
Lily R. Barkau, P.G., Groundwater Section Manager, WDEQ/WQD
Randall Luthi, Policy Director, Office of the Governor, Wyoming (randall.luthi@wyo.gov)
Jason Crowder, Interim Director, Office of State Lands and Investments (Jason.crowder@wyo.gov)
Tom Kropatsch, Oil and Gas Supervisor, Wyoming Oil and Gas Conservation Commission (tom.kropatsch@wyo.gov)
Laramie County Commissioners: Brian Lovett, Chairman, Gunnar Malm, Vice Chairman, Troy Thompson, Commissioner, Linda Heath, Commissioner, and Buck Holmes, Commissioner (commissioners@laramiecountywy.gov)
Travis Bargsten, Branch Chief – Lands and Realty (t75bargs@blm.gov)
Douglas Minter, Chief, USEPA, Region VIII (minter.douglas@epa.gov)
Wendy Cheung, USEPA, Region VIII (cheung.wendy@epa.gov)
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Jessica Gregg, Director, Geoscience Compliance, Tallgrass Energy (jessica.gregg@tallgrass.com)
Katy Larson, Geoscience Compliance Manager, Tallgrass Energy (katy.larson@tallgrass.com)
File

# STATE OF WYOMING
# DEPARTMENT OF ENVIRONMENTAL QUALITY
# UNDERGROUND INJECTION CONTROL PERMIT ISSUED UNDER WYOMING WATER QUALITY RULES CHAPTER 24

**Final Permit No. 2023-041**

**Eastern Wyoming Sequestration Hub**
**Class VI Carbon Sequestration Injection Well**

**Spirea I-1**

**Facility ID No. WYS-021-00155**

**Issued to:**

**Tallgrass High Plains Carbon Storage LLC**
**4200 West 115th Street, Leawood, KS 66211**
**303-763-3319**

**October 2024**
**Version 1.0**

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**ATTACHMENT A-1: Permit Application Dated December 21, 2023**
**ATTACHMENT A-2: Public Notice Affidavit for Application Submittal and Landowner Notification**
**ATTACHMENT A-3: Wyoming Oil and Gas Conservation Commission, Wyoming Office of State Lands and Investment, and Bureau of Land Management Correspondence**
**ATTACHMENT A-4: WDEQ Completeness Review and Permittee Response to Comments**
**ATTACHMENT A-5: Public Notice Affidavit for Draft Permit Public Notice**
**ATTACHMENT A-6: Public Comments and Responses**
**ATTACHMENT A-7: Public Hearing Transcript**

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AoR | Area of Review |
| $^{o}C$ | degrees Celsius |
| CAP | Corrective Action Plan |
| CBL | Cement Bond Log |
| CFR | Code of Federal Regulations |
| $CO_2$ | Carbon Dioxide |
| e.g. | For Example |
| ENS | Earthquake Notification Service |
| ERR | Emergency and Remedial Response |
| ERRP | Emergency and Remedial Response Plan |
| $^{o}F$ | degrees Fahrenheit |
| FOT | Fall-off Pressure Test |
| ft | Feet |
| ft-bgs | feet below ground surface |
| $g/cm^3$ | Grams per cubic centimeter |
| gal | Gallons |
| gpm | gallons per minute |
| in | Inches |
| km | kilometers |
| mg/L | milligrams per liter |
| MIT | Mechanical Integrity Test |
| % | Percent |
| PISC | Post-Injection Site Care |
| psi | pounds per square inch |
| psi/ft | pounds per square inch per foot |
| psig | pounds per square inch - gage |
| § | Section |
| SDWA | Safe Drinking Water Act |
| SRT | Step-Rate Test |
| TDS | Total Dissolved Solids |

| | |
|---|---|
| UIC | Underground Injection Control |
| USDW | Underground Source of Drinking Water |
| USEPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |
| WDEQ | Wyoming Department of Environmental Quality |
| WEQA | Wyoming Environmental Quality Act |
| WOGCC | Wyoming Oil and Gas Conservation Commission |
| W.S. | Wyoming Statute |
| WWQR | Wyoming Water Quality Rules |

## OVERVIEW

This permit is for the construction of one (1) Underground Injection Control (UIC) Class VI carbon sequestration well and associated monitoring wells. This UIC Class VI carbon sequestration well is one of six (6) total injection wells associated with the Eastern Wyoming Sequestration Hub, which is anticipated to inject 137 million metric tonnes over a 30-year operating period. A Certificate of Project consisting of six (6) Class VI injection wells will be issued in accordance with Wyoming Statute (W.S.) § 35-11-313(n).

This permit consists of 10 Sections as follows: Section 1. Permit Issuance; Section 2. Permit Conditions; Section 3. Area of Review and Corrective Action Plan; Section 4. Emergency and Remedial Response; Section 5. Financial Assurance; Section 6. Drilling, Constructing, and Testing; Section 7. Plugging and Abandonment; Section 8. Well Operation; Section 9. Monitoring, Recordkeeping, and Reporting of Results; and Section 10. Post Injection Site Care and Site Closure.

A Reporting and Notification Summary is included in Table 1 which provides a summary of all notification, reporting, and reporting frequency requirements for this permit.

An Injection Depth Waiver (Wyoming Water Quality Rules (WWQR) Chapter 24, Section 15), if required, shall not be issued by the Water Quality Division (WQD) Administrator without receipt of written concurrence from the U.S. Environmental Protection Agency Regional Administrator. Therefore, authorization to inject may not occur until USEPA concurrence on any required Injection Depth Waiter is received.

In accordance with WWQR Chapter 24, Section 4(d), prior to issuing a final permit to authorize injection for a Class VI well, the Director shall consider:

(i) The final area of review based on modeling, using data obtained during logging and testing of the well and the formation as required under WWQR Chapter 24, Section 10;

(ii) Any relevant updates, based on data obtained during logging and testing of the well and the formation, to the information on the geologic structure and hydrogeologic properties of the proposed storage site and overlying formations, as required under WWQR Chapter 24, Section 10.

(iii) The results of the formation testing program, as required under WWQR Chapter 24, Section 10.

(iv) Final injection well construction procedures that meet the requirements of WWQR Chapter 24, Section 14.

(v) Any updates to the proposed Area of Review (AoR) and Corrective Action Plan (CAP), Injection Well-Plugging Plan, Post-Injection Site Care (PISC) and Site Closure Plan, Emergency and Remedial Response Plan (ERRP), and the Financial Assurance Demonstration Plan that are necessary to address new information collected during logging and testing of the well and the formation. The AoR and CAP, Injection Well-Plugging Plan, PISC and Site Closure Plan, ERRP, and Financial Assurance Demonstration Plan submitted as part of the UIC Class VI Permit Application are proposed. Amendments to these Plans must meet the requirements of Wyoming Water Quality Rules (WWQR) Chapter 24, and upon approval of amendments by the Administrator or a Permit Modification by the Director, all plans are incorporated into the permit as a permit condition and are enforceable. If no amendments or modifications are required for a proposed Plan(s), the Plan becomes final upon issuance of the Final UIC Class VI Permit authorizing injection.

## SECTION 1. PERMIT ISSUANCE

In compliance with the Wyoming Environmental Quality Act (WEQA), W.S. § 35-11-101 through 1104, specifically 301(a)(i) through 301 (a)(iv), Laws 1973, Ch. 250, Section 1; W.S. § 31-11-313, Laws 2008, Ch. 30, Section 1; and WWQR, Chapters 24 and 29

Tallgrass High Plains Carbon Storage LLC, 4200 West 115th Street, Leawood, KS 66211

is hereby authorized, contingent upon permit conditions, to construct and conduct pre-injection testing on one (1) UIC Class VI Carbon Sequestration injection well, the Spirea I-1 (Facility ID No. WYS-021-00155), and one (1) monitoring well, the Spirea M-1, as part of the Eastern Wyoming Sequestration Hub located in the SW¼ NW¼ of Section 34, Township 13 North, Range 63 West of the 6th Principal Meridian, in Laramie County, Wyoming for the injection of the carbon dioxide ($CO_2$) stream generated by ethanol plants, ammonia plants, and power plants. This permit is issued for one Class VI well. The $CO_2$ stream is characterized in the permit application (Attachment A-1 of this permit) as a supercritical fluid to be injected into the Lyons Sandstone at depths between 9,447 feet and 9,511 feet below ground surface (ft-bgs) upon the express condition that the Permittee meet the restrictions set forth herein. This injection well, once authorized to inject, shall not exceed an injection volume of eleven (11) million metric tons. **Injection must not commence until the Permittee has received written authorization from the Administrator of the WQD and the Director of the Wyoming Department of Environmental Quality (WDEQ).**

For the Permitted well, the WDEQ will issue an authorization to drill, construct, and operate only after the requirements of Financial Assurance in WWQR Chapter 24, Section 26 have been met. **Tallgrass High Plains Carbon Storage, LLC shall submit an application for a modification of this permit that will grant authorization to inject only after the requirements of WWQR Chapter 24, Sections 14, 17, and 26 have been met and, in accordance with W.S. § 35-11-314-317, a Unitization Order has been issued by the Wyoming Oil and Gas Conservation Commission (WOGCC).**

This permit consists of 38 pages plus the attachments and includes all items listed in the Table of Contents. Further, it is based upon representations made by Tallgrass High Plains Carbon Storage LLC through their application submitted on December 21, 2023, and all additional information submitted by the company and other state and federal agencies as identified in Attachment A. It is the responsibility of the Permittee to read, understand, and comply with all terms and conditions of this permit. The permit to construct becomes effective on the date signed by the Director and remains in full force and effect until site closure is authorized and completed unless this permit is revoked and reissued, terminated, or modified pursuant to WWQR Chapter 24, Sections 6 and 7.

Jennifer Zygmunt, Administrator
Water Quality Division

October 29, 2024
Date

Todd Parfitt, Director
Department of Environmental Quality

October 30, 2024
Date

## SECTION 2. PERMIT CONDITIONS

### A. EFFECT OF PERMIT

Any underground injection activity not specifically authorized by this permit or rule is prohibited. The Permittee must comply with all applicable provisions of the Safe Drinking Water Act (SDWA) and Code of Federal Regulations (CFR) Title 40 §§ 124, 144, 145, and 146. Such compliance does not constitute a defense to any action brought under Section 1431 of the SDWA, U.S. Code, Title 42. § 300(i), or any other common law, statute, or regulation other than Part C of the SDWA. Notwithstanding any other provisions of this permit, the Permittee authorized by this permit must not construct, test, operate, maintain, convert, plug, abandon, or conduct any other injection activity in a manner that allows the movement of injection, annulus, or formation fluids into underground sources of drinking water (USDWs) or any unauthorized injection zones. The objective of this permit is to prevent the movement of fluids into or between USDWs or into any unauthorized injection zones consistent with the requirements of WWQRs Chapter 24.

### B. DEFINITIONS

All terms used in this permit shall have the meaning set forth in WWQR Chapter 24, Section 2. Unless specifically stated otherwise, all references to "days" in this permit should be interpreted as calendar days.

### C. DUTY TO COMPLY

The Permittee shall comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the WWQR and is grounds for enforcement, permit termination, revocation, or modification. Nothing in this permit shall be construed to relieve the Permittee of any duties under applicable regulations.

### D. PERMIT ACTIONS

i. Any modification that may result in a violation of a permit condition shall be reported to the Administrator.

ii. Any modification that will result in a violation of a permit condition shall be reported to the Administrator through the submission of a new or amended permit application.

iii. The Permittee shall give advance notice to the Administrator as soon as possible of any planned physical alterations or additions, other than authorized operation and maintenance, to the permitted facility and receive authorization from the Administrator prior to implementing the proposed alteration or addition.

iv. The Permittee shall notify the Administrator before the conversion or abandonment of the facility. Conversion refers to converting a Class VI well to a Class I, II, or V well. The Permittee shall apply for a permit for Class I and V as specified in WWQR Chapter 27 or Class II through the WOGCC. Upon receipt of the Class I, II, or V permit, the Permittee shall request the permit be terminated as outlined in WWQR Chapter 24 Section 4(d).

v. The Administrator shall review each permit at least once every five (5) years to determine whether it should be modified, revoked and reissued, or terminated.

vi. Filing of a request by the Permittee, or at the instigation of the Administrator, for a permit modification, revocation, termination, or notification of planned changes or anticipated noncompliance, shall not stay any permit condition.

vii. Modification, Revocation and Reissuance, or Termination

1. Permits may be modified, revoked and reissued, or terminated either at the request of any interested person (including the Permittee or licensee) or upon the Administrator's initiative.
2. The Director may modify a permit as identified in WWQR Chapter 24, Section 6.
3. Upon the consent of the Permittee, the Director may modify a permit to make corrections or allowances for minor modifications pursuant to WWQR Chapter 24, Section 6(b). Any permit modification not processed as a minor modification under WWQR Chapter 24, Section 6(b), shall modify the permit pursuant to WWQR Chapter 24, Section 6(a) and conduct public notice as required under WWQR Chapter 24, Section 27.
4. The Director may terminate, revoke and reissue a permit as identified in WWQR Chapter 24, Section 7.

viii. Permit Transfer

1. Transfer of a permit is allowed only upon approval by the Director. The proposed permit transferee shall apply in writing as though that person were the original applicant of the permit, and the proposed permit transferee shall agree to be bound by all of the terms and conditions of the permit.
2. The notice shall be sent at least forty-five (45) days prior to transfer.
3. The Permittee is solely responsible for the operation of the facility covered by this permit. Operation of this facility by another entity is a violation of this permit unless a transfer of this permit has first been authorized.
4. Any transfer of a permit shall be approved by the Director, and no transfer will be approved if the facility is not in compliance with the existing permit unless the proposed Permittee agrees to bring the facility into compliance prior to transfer.
5. A permit may be transferred by modifying the permit or by revoking and reissuing the permit to identify the new Permittee and incorporate the requirements of WWQR Chapter 24 and the WEQA, W.S. § 35-11-101 *et seq.*

ix. When the Permittee becomes aware of the failure to submit any relevant facts in the permit application or that incorrect information was submitted in a permit application or any report to the Administrator, the Permittee must submit such facts or corrected information within ten (10) days of discovery.

## E. PENALTIES FOR VIOLATIONS OF PERMIT CONDITIONS

Any person who violates a permit requirement is subject to civil penalties, fines, and other enforcement actions. Any person who willfully violates a permit condition may be subject to criminal prosecution under the SDWA and other applicable statutes and regulations.

## F. NEED TO HALT OR REDUCE ACTIVITY NOT A DEFENSE

It shall not be a defense for the Permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of the permit.

## G. DUTY TO MITIGATE

The Permittee shall take all reasonable steps to minimize and correct any adverse impact on the environment resulting from noncompliance with this permit.

## H. PROPER OPERATION AND MAINTENANCE

The Permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) that are installed or used by the Permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance include effective performance, testing, equipment calibration, adequate funding and operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of the permit.

## I. PROPERTY RIGHTS

This permit does not convey any property rights or any exclusive privileges. This permit does not authorize any damage to private property or any invasion of personal rights, nor any infringement of federal, state, or local laws or regulations. Proof of notice to surface owners, mineral claimants, mineral owners, lessees and other owners of record of subsurface interests as to the contents of such notice was completed in accordance with W.S. § 35-11-313(ii)(N) and is included in Attachment A-2. WOGCC, Bureau of Land Management, and Wyoming Office of State Lands and Investment were also contacted, and correspondence regarding federal and state land ownership is included in Attachment A-3.

## J. DUTY TO PROVIDE INFORMATION

The Permittee shall furnish to WDEQ, within a time specified, any information which WDEQ may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The Permittee shall also furnish WDEQ, upon request, copies of records required to be kept by this permit. The Permittee must also comply with all reporting requirements of this permit, and as required by WWQR Chapter 24.

## K. INSPECTION AND ENTRY

i. The Permittee shall allow the Administrator, or an authorized representative of the Administrator, upon the presentation of credentials, during normal working hours, to enter the premises where a regulated facility (comprising an injection facility, monitoring facilities, and all associated appurtenances) is located, or where records are kept under the conditions of this permit, and:

1. Inspect the injection and related facilities, practices, or operations regulated or required under this permit;
2. Review and copy reports and records required by this permit;
3. Collect fluid samples for analysis for the purposes of ensuring permit compliance or as otherwise authorized by the WEQA of any substances or parameters at any location;
4. Measure and record water levels, injection pressures, injectate temperatures, and annulus pressures;
5. Collect resource data as defined by W.S. § 6-3-414; and
6. Perform any other function authorized by law or regulation.

ii. If the facility is located on property not owned by the Permittee, the Permittee shall also secure from the landowner upon whose property the facility is located permission for WDEQ personnel and their invitees to enter the premises where the facility is located or where records are kept under the conditions of this permit, and collect resource data as defined by W.S. § 6-3-414, inspect and photograph the facility, collect samples for analysis, review records, and perform any other function authorized by law or regulation. The Permittee shall secure and maintain such access for the duration of the permit and the post-injection site care and site closure period.

iii. If the facility cannot be directly accessed using public roads, the Permittee shall also secure and maintain permission for WDEQ personnel and their invitees to enter and cross all properties necessary to access the facility. The Permittee shall secure and maintain such access prior to spudding wells and for the duration of the permit.

iv. The Permittee shall also maintain in its records a current map of the access route(s) to the facility and contact information for the owners or agents of all properties that must be crossed to access the facility. The Permittee shall ensure that the documentation, map, and contact information are current at all times.

v. Inspectors shall not be required by the Permittee to sign any waiver of liability.

## L. SIGNATORY REQUIREMENTS

All applications, reports, and other information submitted to the Administrator shall contain the certifications required in WWQR Chapter 24, Section 10(d) by a responsible corporate officer.

## M. SEVERABILITY

The provisions of this permit are severable, and if any provision of the permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit shall not be affected.

## N. CONFIDENTIALITY

In accordance with 40 CFR Part 2 and §144.5, and W.S. § 16-4-203(d)(v), any information submitted to WDEQ pursuant to this permit may be claimed as confidential by the submitter. Any such claim must be asserted at the time of submission by stamping the words "confidential business information" on each page containing such information. If no claim is made at the time of submission, WDEQ may make the information available to the public without further notice. If a claim is asserted, the validity of the claim will be assessed and processed in accordance with the provisions of the Wyoming Public Records Act, W.S. §§ 16-4-201 through 205. Claims of confidentiality for the following information will be denied:

i. Name and address of the Permittee, or

ii. Information dealing with the existence, absence, or level of contaminants in drinking water.

## O. PROHIBITIONS

Pursuant to the provisions of W.S. § 35-11-301(a), the Permittee shall not conduct any activities that are identified as prohibited under WWQR Chapter 24, Section 11.

## P. WYOMING CONSERVATION EXECUTIVE ORDERS 2019-3 and 2020-1

i. Executive Order 2019-3 Sage Grouse

The Permittee shall ensure that all activities and habitat disturbances related to injection well(s) authorized by this permit comply with stipulations under the Governor's Executive Order 2019-3 on Greater Sage-Grouse Core Area Protection and are conducted in accordance with Wyoming Game and Fish Department Wildlife Environmental Review recommendations to protect sage-grouse habitat.

No portion of the project authorized by this permit falls within a Sage Grouse Core Area.

ii. Executive Order 2020-1 Migration Corridors

The Permittee shall ensure that all activities and habitat disturbances related to injection well(s) authorized by this permit comply with stipulations under the Governor's Executive Order 2020-1 on Migration Corridors and are conducted in accordance with Wyoming Game and Fish Department Wildlife Environmental Review recommendations to protect migration corridors.

No portion of the project authorized by this permit falls within a Migration Corridor.

## SECTION 3. AREA OF REVIEW AND CORRECTIVE ACTION PLAN

## A. AREA OF REVIEW

i. The AoR for an injection well is the subsurface three-dimensional extent of the $CO_2$ plume, associated pressure front, and displaced fluids, as well as the overlying formations, and surface area above that delineated region. The AoR for this injection well is based on computational modeling that accounts for the physical and chemical properties of all phases of the injected $CO_2$ stream. The AoR and CAP shall include all requirements listed in WWQR Chapter 24 Section 13.

ii. There are no wells that penetrate the confining layer and/or receiver within the AoR specific to Spirea I-1. Therefore, no corrective action is required.

iii. The AoR is depicted in *Figure 3.24 Final AOR Map* in the permit application (Attachment A-1).

1. The final AoR will be based on modeling, using data obtained during logging and testing of the well and the formation as required by WWQR Chapter 24 Sections 10(b)(xviii) – (xxviii).
2. At a fixed frequency, not to exceed two (2) years during the operational life of the facility or five (5) years during the post-injection site care period (until site closure) as specified in the AoR and CAP, or when monitoring and operations conditions warrant, the Permittee shall:

    a. Re-evaluate the AoR in the same manner specified in WWQR Chapter 24 Section 13(b)(i);
    b. Identify all wells in the re-evaluated AoR that require corrective action in the same manner specified in WWQR Chapter 24 Section 13(b)(iv);
    c. Perform corrective action on wells requiring corrective action in the reevaluated AoR in the same manner specified in WWQR Chapter 24 Section 13(b)(v); and
    d. Submit an amended AoR and CAP or demonstrate to the Administrator through monitoring data and modeling results that no change to the AoR and CAP is needed.

iv. Following each AoR reevaluation or a demonstration that no evaluation is needed, the Permittee must submit a report of the resultant information to the Administrator for review and approval.

v. Once approved by the Administrator, the revised AoR and CAP will become an enforceable condition of this permit.

vi. Amendments to the AoR are subject to the permit modification requirements of Section 2.D.viii of this permit.

## B. CORRECTIVE ACTION PLAN

i. If any additional wells requiring corrective action are found within the modified AoR, a list of these wells along with their locations and construction data shall be provided to WDEQ within thirty (30) days of their identification.

ii. The Permittee shall submit a plan to re-enter, plug, and abandon the wells listed in Section 3.A.ii above in a way that prevents the migration of fluids into a USDW. This plan must meet WOGCC plugging requirements.

iii. The Permittee may not commence corrective action activities without prior written approval from WDEQ.

iv. Amendments to a WDEQ-approved CAP are subject to the permit modification requirements of Section 2.D.viii of this permit.

## SECTION 4. EMERGENCY AND REMEDIAL RESPONSE

The ERRP describes actions the Permittee must take to address the movement of the injection or formation fluids that may cause an endangerment to a USDW during construction, operation, and PISC periods. The Permittee must maintain and comply with the approved ERRP (Section *4.1* of the permit application, Attachment A-1), which is an enforceable condition of this permit and with WWQR Chapter 24 Section 25.

i. The ERRP shall be reviewed and updated, as necessary, on the same schedule as the update to the AoR delineation.

ii. Any amendments to the ERRP shall be subject to approval by the Administrator, shall be incorporated into the permit, and are subject to the permit modification requirements of Section 2.D.viii of this permit. Amendments shall be submitted pursuant to WWQR Chapter 24 Section 25(a)(ii)(A) – (C).

iii. The ERRP shall account for the entire AoR delineated pursuant to Section 3.A.iii of this permit.

iv. If any monitoring data or other information indicates that any contaminant, including corrosion or precipitation of minerals, the injected $CO_2$ stream, displaced formation fluids, annulus fluids, or associated pressure front may endanger a USDW or threaten human health, safety, or the environment, the Permittee shall:

1. Immediately cease injection;
2. Take all steps reasonably necessary to identify and characterize any release;
3. Orally notify the Administrator within twenty-four (24) hours of discovering the condition; and
4. Provide a written report to the Administrator within five (5) days of discovering the condition. The written report shall contain:

a. A description of the noncompliance and its cause;
b. The period of noncompliance, including exact dates and times, and, if the noncompliance has not been controlled, the anticipated time it is expected to continue; and
c. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

v. If the Permittee discovers any noncompliance with a permit condition or a requirement of WWQR Chapter 24 that may cause fluid migration into or between USDWs, and malfunction of the injection system that may cause fluid migration into or between USDWs or any excursion, the Permittee shall:

1. Orally notify the Administrator within twenty-four (24) hours of discovering the condition;
2. Provide a written report to the Administrator within five (5) days of discovering the condition, which shall contain:

a. A description of the noncompliance, malfunction, or excursion, and its cause;
b. The period of noncompliance, malfunction, or excursion, including exact dates and times, and, if the noncompliance, malfunction, or excursion has not been controlled, the anticipated time it is expected to continue; and
c. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance, malfunction, or excursion.

vi. If an excursion is discovered, the Permittee shall provide written notice to all surface owners, mineral claimants, mineral owners, lessees, and other owners of record of subsurface interest within thirty (30) days of discovering the excursion.

vii. The Permittee shall implement the ERRP approved by the Administrator.

## SECTION 5. FINANCIAL ASSURANCE

i. The Permittee shall establish, demonstrate, and maintain financial assurance compliant with WWQR Chapter 24 Section 26 for all phases of the geologic sequestration project, including complete site reclamation in the event of default. The phases of a geologic sequestration project are:

1. Permitting/characterization;
2. Testing and monitoring, pursuant to WWQR Chapter 24, Section 20;
3. Operations, including injection and well-plugging, pursuant to WWQR Chapter 24, Sections 18 and 23.
4. PISC, including plume stabilization, monitoring, measurement, verification, corrective action, and other actions needed to ensure that USDWs are not endangered from the time of well-plugging until site closure is certified by the Administrator and above ground-reclamation is completed, pursuant to WWQR Chapter 24, Section 24; and
5. Emergency and remedial response pursuant to WWQR Chapter 24, Section 25.

Proposed qualifying financial assurance instruments to be utilized to demonstrate financial responsibility are provided in the *Financial Assurance Demonstration Plan, Section 4.2* in the permit application (Attachment A-1); response to comments dated May 9, 2024, and supplemental information submitted July 5 and 13, 2024 (Attachment A-4).

ii. The Permittee shall develop and annually update in accordance with WWQR Chapter 24, Section 26(f), a written financial assurance cost estimate. The Permittee shall submit the updated financial assurance cost estimate to the Administrator annually within thirty (30) days of the anniversary date when the original financial assurance cost estimate was submitted.

iii. The financial assurance cost estimate shall include the cost in current dollars and must cover the cost of:

1. Performing corrective action on other wells in the AoR that require corrective action under Chapter 24, Section 13;
2. Plugging the injection wells under Chapter 24, Section 23;
3. PISC and Site Closure under Chapter 24, Section 24;
4. Testing and monitoring under Chapter 24, Section 20; and
5. Emergency and Remedial Response under Chapter 24, Section 25.

iv. The Permittee estimates the corrective action cost pursuant to WWQR Chapter 24 Section 13 to be **$0**. No wells that penetrate the receiver or confining layers are located in the AoR and therefore, no corrective action is required.

v. The Permittee estimates the injection well-plugging cost pursuant to WWQR Chapter 24 Section 23 to be **$597,000**. Surface reclamation for the injection well, removal of the flow line, ancillary surface structures associated with the well, and soil grading and seeding will be covered under PISC.

vi. The Permittee estimates the PISC and Site Closure to be **$16,893,505**. The PISC will cover the costs associated with monitoring during the post-injection phase, the surface reclamation and plugging of monitoring well(s), surface reclamation activities associated with the injection well, and the plugging and surface reclamation of soil gas monitoring points.

vii. The Permittee estimates the ERR costs pursuant to WWQR Chapter 24 Section 25, by considering the cost of emergency and remedial response actions and WWQR event-based risk activities (WWQR Chapter 24, Appendix A). Technical manuscripts by Trabucchi and others (2014) were used to identify and estimate the costs of mitigation and remediation technologies to address the undesired migration of $CO_2$ from a geological storage reservoir. The dollar amount was calculated by evaluating the probability of $CO_2$ leakage from the wellbore, and/or through the caprock and fault(s). The Permittee's estimate for ERR actions is **$5,800,553**.

viii. The Permittee shall obtain and maintain public liability insurance for the geologic sequestration project. The requirements for public liability insurance are listed in WWQR Chapter 24 Section 26(l).

ix. The financial responsibility instruments used shall be from the list of qualifying instruments identified in WWQR Chapter 24 Section 26(c) and submitted on a WDEQ form. Qualifying financial responsibility instruments are subject to approval by the Director.

x. Total financial responsibility for the injection well is summarized in Table 2. A complete breakdown of the costs to establish financial assurance and used to assess the appropriate coverage is presented in the *Financial Assurance Demonstration Plan, Section 4.2* in the permit application (Attachment A-1); response to comments dated May 9, 2024, and supplemental information submitted July 5 and 13, 2024 (Attachment A-4).

## SECTION 6. DRILLING, CONSTRUCTING, AND TESTING

The design and specifications for the injection well, injection zone monitoring wells, confining zone monitoring wells, groundwater monitoring wells, and any other monitoring system are included in *Specific Comments 18 and 24* of the May 9 and July 5, 2024, response to comments (Attachment A-4) and Section 4.4 *Well Casing and Cementing Program* of the permit application (Attachment A-1). Injection shall not commence until construction is complete and a Final Report including a notice of completion is submitted to the Administrator for review and approval. Once the Final Report is approved, the Permittee shall submit an application for a modification of this permit or request for authorization to inject if no modification is necessary that will grant authorization to inject only after the requirements of WWQR Chapter 24, Sections 14,17, and 26 have been met and, in accordance with W.S. §§ 35-11-314 through 317, a Unitization Order has been issued by the WOGCC.

### A. SITING

i. The Permittee has demonstrated that the well is in an area with suitable geology based on WDEQ's review of Section 2.0, *Site Characterization* of the permit application (Attachment A-1) in accordance with WWQR Chapter 24, Section 12 requirements.

ii. The groundwater in the Lyons Sandstone is expected to be classified as Class VI (unusable/unsuitable) in accordance with WWQR, Chapter 8 Section 4 (d)(ix). This expected classification is made because:

1. The depths of these formations are such that the production of water from them is not economically nor technically practical.
2. Total Dissolved Solids (TDS) concentrations are expected to be greater than 10,000 milligrams per Liter (mg/L) which does not meet the definition of a USDW.

   A USDW means an aquifer or portions thereof that is not an exempted aquifer and:

   a. Supplies any public water system; or
   b. Contains a sufficient quantity of groundwater to supply a public water system, and
   c. Currently supplies drinking water for human consumption; or
   d. Contains fewer than 10,000 mg/L TDS.

iii. This groundwater classification will become final once baseline samples are taken from the Lyons Sandstone during the drilling and completion of the injection well. Tables 3 through 5 identify the constituents to be analyzed for the groundwater classification.

iv. The aquifer Class VI designation is limited to the AoR as defined in Section 3.A.iii of this permit.

v. The proposed injection zone is as follows:

1. The Lyons Sandstone is estimated to be an approximately sixty-four (64) foot (ft) thick zone encountered below 9,447 ft-bgs.
2. These formation depths are estimated and shall be confirmed during well drilling and completion activities.

vi. The proposed confining zones are as follows:

1. The Chugwater and Goose Egg Formations overlie the Lyons Sandstone and consist of interbedded shale and siltstones with an average combined thickness of approximately 500 feet in the area of the injection well.
2. The Satanka and Wolfcamp Formations underlie the Lyons Sandstone and consists of interbedded sandstone, siltstone, mudstone, marlstone, and anhydrite, with an average thickness of 292 feet in the area of the injection well.
3. These formation thicknesses are estimated and shall be confirmed during well drilling and completion activities.

vii. Any relevant updates based on data obtained during logging and testing of the well and the formation, to the information on the geologic structure and hydrogeologic properties of the proposed storage site and overlying formations, are subject to the permit modification requirements of Section 2.D.viii of this permit.

viii. Data obtained during logging and testing of the well or monitoring wells for the project indicating that a USDW is currently located below the proposed injection zone will require an Injection Depth Waiver in accordance with WWQR Chapter 24, Section 15. A separate report that meets requirements of WWQR Chapter 24, Section 15 is required to be submitted to WDEQ for review and approval. An Injection Depth Waiver shall not be issued by WDEQ until receipt of written concurrence from the USEPA occurs.

## B. WELL CONSTRUCTION

i. INJECTION WELL CONSTRUCTION

1. The Permittee shall design, construct, and complete all Class VI wells to meet all construction standards in WWQR Chapter 24 Section 14 and to:

a. Prevent the movement of fluids into or between USDWs or into any unauthorized zones;
b. Allow the use of appropriate testing devices and workover tools; and
c. Allow continuous monitoring of the annulus space between the injection tubing and long string casing.

2. The injection facility covered by this permit shall meet the construction requirements outlined in WWQR Chapter 24 Section 14. The design and construction must allow continuous monitoring of the annulus between the long string casing and the injection tubing from the packer to the surface and accommodate testing devices and workover tools.
3. During the construction, the Permittee may make changes to the design of the injection well consistent with the conditions of this permit. If changes are made to the design of the well, notification must be made to WDEQ for review and approval by the Administrator before installation.
4. Once construction is completed, and prior to authorization to inject, the Permittee must submit the final, as-built construction specifications and diagrams within thirty (30) days for review and approval by the Administrator. Any deviations from the proposed design and as-built construction of the well must be noted.
5. Changes in construction plans during construction may be approved by the Administrator as minor modifications. No such changes may be physically incorporated into the construction of the well prior to the approval of the modification by the Administrator. Proposed changes and workovers will require a plan to be submitted to WDEQ for review and approval. Any deviations from the WDEQ-approved plans must receive WDEQ approval prior to implementation.
6. If the changes in well design are significant, the Administrator may require the permit to be modified.
7. The Permittee shall submit a Final Construction Report, including a notice of completion of construction to the Administrator.
8. The Permittee shall allow the Administrator to inspect the facility upon completion of construction and prior to commencing any underground injection activity. The Permittee shall provide the Administrator with the opportunity to witness all logging and testing of the injection well.

ii. WELL LOCATION

1. The injection well authorized under this permit will be located in Laramie County, Wyoming. The proposed general location for the well is found in *Figure 1.1* of in the permit application (Attachment A-1) and revised *Table 1.1* of the supplemental information submitted July 17, 2024 (Attachment A-4).
2. After drilling is completed, the Permittee must submit final field coordinates (Section, Township, Range, with latitude/longitude) of any injection or monitoring well constructed under this permit. If the final well coordinates differ from the proposed coordinates submitted under paragraph (a) above, justification and documentation of any communication with and approval by WDEQ shall be included.
3. In addition, the Permittee shall submit final survey data and reports upon completion of the drilling operations.

iii. CASING AND CEMENTING

The well must be cased and cemented in accordance with WWQR Chapter 24 Section 14(b). Casing and cement or other materials used in the construction of a Class VI well shall have sufficient structural strength and be designed for the life of the well. All well materials shall be compatible with fluids with which the materials may be expected to come in contact and

shall meet or exceed the standards identified in WWQR Chapter 24 Section 14(b)(i)(A) – (H). The casing and cement used in the construction of the well are shown in Section 4.4 *Well Casing and Cementing Program* in the permit application (Attachment A-1) and response to comments dated May 9, 2024, and supplemental information submitted July 5, 2024 (Attachment A-4). Any changes must be submitted to the Administrator for approval before installation.

iv. TUBING AND PACKER SPECIFICATIONS

The tubing and packer design must meet the requirements in accordance with WWQR Chapter 24 Section 14(c). The Permittee shall inject fluids through tubing with a packer set at a depth opposite a cemented interval at the location approved by the Administrator. Tubing and packer materials used in the construction of the Class VI well shall be compatible with fluids with which the materials may be expected to come into contact and shall meet or exceed the standards identified in WWQR Chapter 24 Section 14(c)(i)(A) – (H). The injection must only take place through the tubing, with a packer set in the long string casing within or below the nearest cemented and impermeable confining system no more than 100 feet above the injection zone. The tubing and packer used in the well are shown in permit application Section 4.4 *Well Casing and Cementing Program* (Attachment A-1). Any changes must be submitted to the Administrator for approval before installation.

v. DATA COLLECTION

1. The Permittee shall take whole cores or sidewall cores of the injection zone and confining system as well as formation fluid samples from the injection zone.
2. The Permittee shall record the formation fluid temperature, formation fluid, pH and conductivity, reservoir pressure, and static fluid level of the injection zone.
3. Tests to determine well-specific data regarding the injection and confining zones shall be conducted to determine fracture pressures of the injection and confining zones and verify hydrogeologic and geo-mechanical characteristics of the injection zone by conducting a pressure fall-off test (FOT), and any other test requested by the Administrator including:

    a. A pump test; or
    b. Injectivity test.

vi. MONITORING WELL CONSTRUCTION

Monitoring of the groundwater quality and geochemical changes above the confining zones that may be a result of $CO_2$ movement or displaced formation fluid movement through the confining zones or additional zones is required per WWQR Chapter 24 Section 20. Monitoring includes monitoring for all USDWs above the confining zone. Groundwater, confining zone, and injection zone monitoring wells must be constructed as depicted in Section 4.4 *Well Casing and Cementing Program* in the permit application (Attachment A-1) and response to comments dated May 9, 2024, and supplemental information submitted July 5, 2024 (Attachment A-4). Additional monitoring wells beyond what is depicted in Section 4.4 *Well Casing and Cementing Program*, may be required based on site-specific data collected during drilling, completion, and operation at the facility. All monitoring wells must be constructed in a manner to provide representative samples that can be analyzed for the monitoring parameters required by this permit. Once the construction of the monitoring wells has been completed, the as-built construction diagrams must be included in the Pre-

injection Testing Report to be submitted to the Administrator per Section 6.B.vii of this permit.

vii. FINAL WELL CONSTRUCTION REPORT
The Permittee must submit a Final Well Construction Report, including a narrative description and timeline for the well construction and completion activities, summary of any deviation(s) from the approved well drilling and completion plan, report of formation tops from surface to the total depth of the well, analysis of the Cement Bond Log (CBL), daily reports, logging, coring, and other results, with a schematic diagram and detailed description of construction, including driller's log, materials used (i.e., tubing tally, particulate filters), if any, and cement (and other) volumes, Part I and II Mechanical Integrity Tests (MIT), to WDEQ within thirty (30) days after completion of any of the permitted injection or monitoring well(s) or with the next quarterly report, whichever is later.

## C. PRE-INJECTION REQUIREMENTS

i. Prior to authorization of injections, the Permittee must perform all pre-injection logging, sampling, and testing as required in WWQR Chapter 24 Section 17.

ii. The pre-injection testing plan is included in Section 4.3 *Testing and Monitoring Plan* of the permit application (Attachment A-1) and response to comments dated May 9, 2024, and supplemental information submitted July 5, 2024 (Attachment A-4).

iii. The Permittee shall run appropriate logs, surveys, and tests to determine or verify the depth, thickness, porosity, permeability, lithology, and salinity of any formation fluids in all relevant geologic formations to ensure the well meets the construction requirements of WWQR Chapter 24 Section 14 and to establish accurate baseline data against which future measurements may be compared. The appropriate logs are identified in Chapter 24 Section 17 and summarized in Table 11 of this permit.

iv. The Permittee shall submit to the Administrator a descriptive report prepared by a knowledgeable log analyst that includes an interpretation of the results of the logs and tests. At a minimum, the logs and tests shall include:

1. Deviation checks that meet the requirements of WWQR Chapter 24 Section 17(a)(i);
2. Logs and test before and upon installation of the surface casing that meets the requirements of WWQR Chapter 24 Section 17(a)(ii);
3. Logs and tests before and upon installation of the long string casing that meets the requirements of WWQR Chapter 24 Section 17(a)(iii);
4. CBLs over the course of the entire cased hole section after each casing is set and cementing is completed. The CBL evaluation shall enable analysis of bond between cement and casing, as well as between cement and formation, and shall allow detection and assessment of any micro-annulus between the casing and cement as well as any cement channeling in the borehole annulus. CBL output tracks shall include gamma, amplitude, CBL waveform, and cement image. CBL shall be conducted no sooner than seventy-two (72) hours from the last cement job to ensure adequate cement curing;

5. Formation fluid sample information, including but not limited to formation fluid temperature, formation fluid pH and conductivity, reservoir pressure, and static fluid level of the injection zone;
6. Part I and II MITs designed to demonstrate the internal and external mechanical integrity of injection wells identified in WWQR Chapter 24 Sections 17(a)(iv) and 19;
7. Any alternative methods that provide equivalent or better information and that are required or approved by the Administrator.

v. The Permittee shall submit a schedule for pre-operational testing activities thirty (30) days prior to conducting the first test and submit any changes to the schedule thirty (30) days prior to the next scheduled test. The Permittee must provide the Administrator with the opportunity to witness all logging, sampling, and testing required under this section.

**SECTION 7. PLUGGING AND ABANDONMENT**

The Permittee shall comply with the approved *Well Plugging Plan* (Section 4.5 of the permit application, Attachment A-1) and must comply with the requirements of WWQR Chapter 24 Section 23. The Well Plugging Plan is an enforceable condition of this permit. Any deviations from the WDEQ-approved Plugging Plan must receive WDEQ approval prior to implementation.

i. The Permittee shall prepare, maintain, and update on the same schedule as the update to the AoR delineation, and comply with a well-plugging plan that is approved by the Administrator. The well-plugging plan shall include the information pursuant to WWQR Chapter 24 Section 23(b)(i) – (vi).

ii. Any amendments to the Well Plugging Plan must be approved by the Administrator and must be incorporated into the permit and are subject to the permit modification requirements of WWQR Chapter 24 Section 6.

iii. Prior to well plugging, the Permittee shall flush each injection well with a buffer fluid, determine bottom hole reservoir pressure, and perform a Part I MIT in accordance with WWQR Chapter 24 Section 19.

iv. The Permittee shall notify the Administrator, in writing, at least sixty (60) days before plugging a well.

v. Within sixty (60) days after completion of plugging and abandonment of a well, the Permittee shall submit to the Administrator a final report that includes the information pursuant to WWQR Chapter 24 Section 23(e)(i) – (ii).

vi. If the plugging differed from the approved plan, the Permittee shall submit a statement describing the actual plugging and an updated plan specifying the differences from the plan previously submitted and explaining why the Administrator should approve the deviation. If the Administrator determines that a deviation from the plan incorporated in the permit may endanger the USDW, the Permittee must re-plug the well as required by the Administrator.

vii. The well-plugging report required under WWQR Chapter 24 Section 23 shall be retained for ten (10) years following site closure.

viii. The Permittee must deliver the records to the Administrator at the conclusion of the retention period.

## SECTION 8. WELL OPERATION

Operation of the Class VI injection well shall not occur until a modified permit authorizing the injection is issued. Authorization to inject may only occur after all conditions and requirements of WWQR Chapter 24, and this permit have been met. Authorization may be issued under a modified permit. Sections 8.A and 8.B establish the maximum injection volumes and pressure necessary to ensure that fractures are not initiated in the confining zone, to ensure that injected fluids do not migrate into any USDW, to ensure that formation fluids are not displaced into any USDW, and to ensure compliance with the operating requirements.

### A. INJECTION PRESSURE LIMITATION

i. Except at specific times as approved by the Administrator, the Permittee must maintain on the well a pressure that will prevent the return of the injection fluid to the surface. The well bore must be filled with a fluid of sufficient specific gravity during workovers to maintain a positive (downward) pressure gradient and/or a plug shall be installed which can resist the pressure differential. A blowout preventer must be installed and kept in proper operational condition whenever the wellhead is removed to work on the well. The Permittee must follow procedures such as those below to assure that a backflow or blowout does not occur:

1. Limit the temperature and/or corrosivity of the injectate; and
2. Develop procedures necessary to assure that pressure imbalances do not occur.

ii. The Permittee shall ensure that injection pressure does not exceed ninety percent (90%) of the fracture pressure of the injection zone(s) to ensure that the injection does not initiate new fractures or propagate existing fractures in the injection zone(s). In no case may injection pressure cause movement of injection or formation fluids in a manner that endangers a USDW, or otherwise threatens human health, safety, or the environment, or initiate fractures in the confining zones or cause the movement of injectate or formation fluids that endangers a USDW, or otherwise threatens human health, safety, or the environment.

iii. During operation, the injection pressure will be measured at the wellhead and at the injection interval.

iv. The pressure limitations presented in Table 6 of this permit are temporary limits based on calculations presented in Section 5.0 *Injection Well Operations* of the permit application (Attachment A-1). These limitations are temporary, permanent limitations will be based on the results of injection tests to be conducted on the injection well. No injections of $CO_2$ will be allowed into the injection well until pre-injection testing is conducted to identify the pressure limitations.

v. After the well is constructed, the Maximum Injection Pressure will be recalculated using a fracture gradient measured from the step-rate test (SRT) or other approved injectivity test

that will be conducted in the injection well, and the actual depth of the top of the injection zone.

## B. STIMULATION PROGRAM

All stimulation activities must be approved by the Administrator prior to conducting stimulation. The Permittee must carry out the Stimulation Program in accordance with response to comments dated May 9, 2024 (Attachment A-4).

## C. ADDITIONAL INJECTION LIMITATIONS

No injection fluid other than that identified in Section 1 of this permit may be injected except fluids used for stimulation, rework, and well tests as approved by the Administrator. Injection must occur within the injection tubing.

## D. ANNULUS FLUID

The Permittee must fill the annulus between the tubing and the long string casing with a non-corrosive fluid approved by the Administrator.

## E. ANNULUS/TUBING PRESSURE DIFFERENTIAL

Except during workovers or times of annulus maintenance, the Permittee must maintain pressure on the annulus that exceeds the operating injection pressure as specified in permit application Section 5.0 *Injection Well Operations* (Attachment A-1), unless the Administrator determines that such requirement might harm the integrity of the well or endanger USDWs. This annulus pressure limitation is temporary, and permanent limitations will be based on the results of SRT or other approved injectivity tests to be conducted on the injection well. No injections of $CO_2$ will be allowed into the injection well until the pre-injection test is conducted to identify the pressure limitations.

## F. AUTOMATIC ALARMS AND AUTOMATIC SHUT-OFF SYSTEM

The Permittee shall install, test, and use alarms and automatic surface shut-off systems or, at the discretion of the Administrator, use down-hole shut-off systems (e.g., automatic shut-off, check valves) or other mechanical devices that provide equivalent protection, designed to alert the Permittee and shut-in the well when operating parameters such as injection rate, injection pressure, annulus pressure, or other parameters approved by the Administrator diverge beyond ranges or gradients specified in the permit.

If an automatic shutdown is triggered or a loss of mechanical integrity is discovered, the Permittee shall immediately investigate and identify as expeditiously as possible the cause. If, upon such investigation, the well appears to be lacking mechanical integrity, or if monitoring required under WWQR Chapter 24 Section 18(e) – (g) otherwise indicates that the well may be lacking mechanical integrity, the Permittee shall:

i. Immediately cease injection;

ii. Take all steps reasonably necessary to determine whether there may have been a release of the injected $CO_2$ stream or formation fluids into any unauthorized zone;

iii. Notify the Administrator within twenty-four (24) hours;

iv. Restore and demonstrate mechanical integrity to the satisfaction of the Administrator as soon as practicable and prior to resuming injection; and

v. Notify the Administrator when injection can be expected to resume. Approval to resume injections is required from the Administrator.

## G. MECHANICAL INTEGRITY

i. The Permittee shall establish mechanical integrity prior to commencing injection and maintain mechanical integrity as defined in WWQR Chapter 24 Section 19.

ii. To evaluate the absence of significant leaks (in the casing, tubing, or packer), the Permittee shall continuously monitor injection pressure, rate, injected volumes, and pressure on the annulus between tubing, long string casing, and annulus fluid volume as specified in WWQR Chapter 24 Section 18(e) – (f).

iii. The Permittee shall maintain mechanical integrity, as defined in WWQR Chapter 24, Section 19, of the injection well at all times except during periods of well workover or maintenance approved by the Administrator in which the sealed tubing-casing annulus is, by necessity, disassembled for maintenance or corrective procedures.

iv. The Permittee shall use one (1) of the following methods to determine the absence of significant fluid movement under subparagraph (a)(ii) of WWQR Chapter 24 Section 19 at least once per year:

1. An approved tracer survey, such as an oxygen-activation log; or
2. A temperature log or a noise log such as pulse echo, ultrasonic image, or equivalent.

v. If the Administrator determines that a Class VI well lacks mechanical integrity and gives written notice of the determination to the Permittee, the Permittee shall:

1. Cease injection in the well within forty-eight (48) hours of receipt of the Administrator's determination unless the Administrator requires immediate cessation;
2. Perform any construction, operation, monitoring, reporting, and corrective action that the Administrator requires to prevent the movement of fluid into or between USDWs caused by the lack of mechanical integrity, or plug the well pursuant to the requirements of WWQR Chapter 24 Section 23 if allowed by the Administrator; and
3. Not resume injection into the well until the Administrator provides written notice that the Permittee has demonstrated mechanical integrity pursuant to WWQR Chapter 24 Section 19.

vi. The Permittee shall run a casing inspection log to determine the presence or absence of corrosion in the long-string casing as specified in the *Testing and Monitoring Plan* (permit application Section 4.3, Attachment A-1).

vii. For any Class VI well that lacks mechanical integrity, injection operations are prohibited until the Permittee shows to the satisfaction of the Administrator under WWQR Chapter 24 Section 19 that the well has mechanical integrity.

## H. SEISMIC EVENT RESPONSE

i. A seismicity monitoring system, or array, shall be installed and implemented as part of seismicity monitoring of the subsurface surrounding the injection well. The seismic array shall be capable of monitoring real-time seismic activity, providing an ability to evaluate whether any seismicity recorded is related to injection activities. The seismic array will be able to accurately resolve the focal depth and hypocenter of earthquakes of Local Magnitude 1.0 and above that occur within a 10-kilometer (km) radius of the most currently modeled and approved AoR. Any seismic activity detected will be transmitted by a cellular network and recorded at a central server, where information on the number of events, magnitudes, and slant distances from the seismic array will be stored.

ii. A work plan for the installation and operation of the seismic array shall be provided to WDEQ prior to any drilling activities. The seismic array shall be installed prior to any injection in order to collect background and ambient noise, for which the seismographs' calibration shall be adjusted to maintain the intended seismic monitoring fidelity.

iii. The seismic array should provide seismic monitoring for background seismicity signatures for at least six (6) months prior to the installation of the injection well.

iv. The United States Geological Survey (USGS) Earthquake Hazards Program operates an email notification service that reports real-time earthquake events for any events for any area specified by the user. The Permittee is required to subscribe to this service, known as the Earthquake Notification Service (ENS). Details for the ENS can be found at https://earthquake.usgs.gov/ens/, and a subscription can be initiated at https://earthquake.usgs.gov/ens/register.

v. All seismicity recorded by the seismic array above Moment Magnitude 1.0 shall be recorded, with hypocenters resolved as accurately as possible, and reported to WDEQ on a quarterly basis.

vi. Information obtained during drilling, logging, reservoir testing, and seismicity investigations shall be used to update the reservoir model. At the time of the permit modification, this information will be used to inform any required permit actions due to seismicity, induced or natural, that may occur during the life of the project.

# SECTION 9. MONITORING, RECORDKEEPING, AND REPORTING OF RESULTS

The specific measurement and reporting frequencies are listed in Table 1. All data and reports required by this permit are to be submitted in an electronic format as approved by the Administrator.

## A. TESTING AND MONITORING REQUIREMENTS

i. TESTING AND MONITORING PLAN

The Permittee must maintain and comply with the approved *Testing and Monitoring Plan* (permit application Section 4.3, Attachment A-1), response to comments dated May 9, 2024 and supplemental information submitted July 5, 2024 (Attachment A-4), and with the requirements of WWQR Chapter 24 Section 20, and any modifications required by the Administrator after the effective date of the permit. Site-specific data collected during the drilling and testing of the Class VI injection well will be used to update the Testing and Monitoring Plan prior to authorization to inject being issued. The Testing and Monitoring Plan is an enforceable condition of the permit. Samples and measurements taken for the purpose of monitoring must be representative of the monitored activity.

1. The Permittee shall prepare, maintain, and comply with the testing and monitoring plan to verify that the geologic sequestration project is operating as permitted and is not endangering USDWs as specified in WWQR Chapter 24 Section 20 and W.S. § 35-11-313.
2. Injection wells in or near in proximity to a wellhead protection area or a source water protection area require additional monitoring. The monitoring must be performed as described in the *Testing and Monitoring Plan* response to comments dated May 9, 2024 (Attachment A-4).
3. Amended plans or demonstrations shall be submitted to the Administrator as specified in WWQR Chapter 24 Section 20(b)(xi) – (xii).
4. The Permittee shall create and retain records of all monitoring information as specified in WWQR Chapter 24 Section 20(c).
5. The Permittee shall review the Testing and Monitoring Plan to incorporate monitoring data, operational data, and the most recent AoR reevaluation performed under this permit. The Permittee shall review the Testing and Monitoring Plan every five (5) years. Based on this review, the Permittee shall submit an amended Testing and Monitoring Plan or demonstrate to the Administrator that no amendment to the Testing and Monitoring Plan is needed. Any amendments to the Testing and Monitoring Plan are subject to approval by the Administrator, shall be incorporated into this permit, and are subject to the permit modification requirements of WWQR Chapter 24 Section 6. Amended plans or demonstrations shall be submitted to the Administrator as follows:

    a. Within one (1) year of an AoR reevaluation;
    b. Following any significant changes to the facility, such as the addition of monitoring wells or newly permitted injection wells within the AoR; or
    c. When required by the Administrator.

ii. $CO_2$ STREAM ANALYSIS

The Permittee must analyze the $CO_2$ stream with sufficient frequency to yield data representative of its chemical and physical characteristics, as described in the Testing and Monitoring Plan (permit application Section 4.3, Attachment A-1) and WWQR Chapter 24 Section 20 (Table 7 of this permit). **The $CO_2$ purity has been determined to be >95%.** The Permittee has submitted its certification that no hazardous waste will be mixed or

otherwise co-injected with the $CO_2$ stream and the $CO_2$ stream is excluded as a hazardous waste under 40 CFR 261.4(h) (Attachment A-1).

iii. CONTINUOUS MONITORING

The Permittee must install and use, except during well workovers, continuous recording devices to monitor injection pressure, injection rate and volume, pressure on the annulus between the tubing and the long string casing, and the annulus fluid volume added. The monitoring must be performed as described in the *Testing and Monitoring Plan* (permit application Section 4.3, Attachment A-1), response to comments dated May 9, 2024 and supplemental information submitted July 5, 2024 (Attachment A-4), and WWQR Chapter 24 Section 20 (Table 9 of this permit). The Permittee must maintain for WDEQ's inspection at the facility an appropriately scaled, continuous record of these monitoring results as well as original files of any digitally recorded information pertaining to these operations.

iv. CORROSION MONITORING

The Permittee shall perform corrosion monitoring of the well materials for loss of mass, loss of thickness, cracking, pitting, and other signs of corrosion, which shall be performed and recorded at least quarterly to ensure that the well components meet the minimum standards for material strength and performance as set forth in WWQR Chapter 24 Section 14(b).

v. GROUNDWATER MONITORING ABOVE THE CONFINING ZONE

Periodic monitoring of the groundwater quality and geochemical changes above the confining zones that may be a result of $CO_2$ movement or displaced formation fluid movement through the confining zones or additional zones is required. All monitoring conducted must be performed for the parameters identified in the approved *Testing and Monitoring Plan* at the locations and depths and at the frequencies described in the *Testing and Monitoring Plan* (Section 4.3 of the permit application, Attachment A-1) Table 8 of this permit.

vi. CARBON DIOXIDE PLUME AND PRESSURE FRONT TRACKING

The Permittee must track the extent of the $CO_2$ plume and pressure front using direct and indirect monitoring methods as described in the *Testing and Monitoring Plan* (permit application Section 4.3, Attachment A-1. The Permittee is required to conduct this monitoring in order to detect and locate the $CO_2$ pressure front and the dissolved $CO_2$ plume, and the data will be used to calibrate the AoR model to determine whether modifications to the AoR are needed. Data collected by the following methods will be used to monitor the location of the plume and pressure front, evaluate its movement through time, and to compare to the plume and pressure front predictions of the AoR model:

1. Direct Methods in the injection zone(s); and
2. Indirect Methods in the injection zone (e.g., seismic, electrical, gravity, or electromagnetic surveys and/or down-hole carbon dioxide detection tools) unless the Administrator determines based on site-specific geology, that such methods are not appropriate.
3. Direct and Indirect Methods described in the *Testing and Monitoring Plan* (permit application Section 4.3, Attachment A-1 shall be followed.

viii. PART II MECHANICAL INTEGRITY TESTING
The Permittee must demonstrate Part II MIT pursuant to the *Testing and Monitoring Plan* (permit application Section 4.3, Attachment A-1 at least once per year until the well is plugged.

ix. PRESSURE FALL-OFF TEST
The Permittee must conduct pressure FOT that identifies reservoir conditions with respect to flow dynamics at least once every five (5) years, unless more frequent testing is required by the Administrator based on site-specific data (permit application Section 4.2, *Testing and Monitoring Plan*, Attachment A-1).

x. SURFACE AIR AND/OR SOIL GAS MONITORING
The Permittee must conduct soil gas monitoring pursuant to the *Testing and Monitoring Plan* and response to comments dated May 9, 2024 (Attachment A-4). The frequency and spatial distribution of soil gas monitoring shall be based on baseline data to be collected during the drilling and testing of the injection well.

xi. PROPOSED CHANGES AND WORKOVERS
1. Demonstration of mechanical integrity shall be performed within thirty (30) days of completion of workovers or alterations and prior to resuming injection activities, in accordance with Section 8.G of this Permit.
2. The Permittee shall provide a procedure to complete workovers or changes to WDEQ for review and approval prior to initiating the proposed work.
3. The Permittee shall provide all records of well workovers, logging, or other subsequent test data, including required MIT, to WDEQ within thirty (30) days of completion of the activity or with the next quarterly report, whichever is later.

## B. REPORTING AND NOTICE REQUIREMENTS

The Permittee must submit reports at frequencies described in the approved *Testing and Monitoring Plan* and as required by the permit. Reports must contain all data and information required to be monitored, gathered, and reported by this permit and meet the requirements of WWQR Chapter 24 Section 21. A summary of all reporting requirements, frequency, and submittal due dates is identified in Table 1.

i. The Permittee shall submit all required reports, submittals, and notifications to the Administrator in a format acceptable to WDEQ.

ii. The Permittee shall report all instances of noncompliance not already required to be reported under 9.B.v of this permit, at the time monitoring reports are submitted. The reports shall contain the information in Section 9.B.v of this permit.

iii. Semi-annual Reports
The Permittee shall submit semi-annual reports to the Administrator thirty (30) days following the end of the period covered in the report and shall contain:

1. Any changes to the physical, chemical, and other relevant characteristics of the $CO_2$ stream from the proposed operating data;

2. Monthly average, maximum, and minimum values for injection pressure, flow rate and volume, and annular pressure;
3. A description of any event that exceeds operating parameters for annulus pressure or injection pressure as specified in the *Testing and Monitoring Plan* (permit application Section 4.3, Attachment A-1);
4. A description of any event that triggers a shutdown device required pursuant to WWQR Chapter 24 Section 18(g) and Section 8.F of this permit and the response taken;
5. The monthly volume of the $CO_2$ stream injected over the reporting period and project cumulatively;
6. Monthly annulus fluid volume added; and
7. The results of the monitoring required by WWQR Chapter 24 Section 20 and the *Testing and Monitoring Plan* (permit application Section 4.3, Attachment A-1).

iv. Reports

The Permittee shall submit a Report within thirty (30) days, the results of:

1. Periodic test of mechanical integrity;
2. Any other test of the injection well conducted by the Permittee if required by the Administrator; and
3. Any well workover.

v. Twenty-Four (24) Hour Reporting

1. The Permittee must report to the Administrator any permit noncompliance which may endanger human health or the environment and any events that require implementation of actions in the *ERRP* (permit application Section 4.1, Attachment A-1). Any information must be provided orally within twenty-four (24) hours from when the Permittee becomes aware of the circumstances. Such verbal reports must include, but not be limited to, the following information:

    a. Any evidence that the injected $CO_2$ stream or associated pressure front may cause an endangerment to a USDW;
    b. Any noncompliance with a permit condition or malfunction of the injection system, which may cause fluid migration into or between USDWs;
    c. Any triggering of a shut-off system, either down-hole or at the surface;
    d. Any release of $CO_2$ to the atmosphere or biosphere indicated by the surface air or soil gas monitoring or other monitoring technologies required by WWQR Chapter 24 Section 20(b)(ix) and Section 9.A.x of this permit; and
    e. Any failure to maintain mechanical integrity.

2. The Permittee must report to the Administrator actions taken to implement appropriate protocols outlined in the *ERRP* (permit application Section 4.1, Attachment A-1).
3. A written submission must be provided to the Administrator within five (5) days of the time that the Permittee becomes aware of the circumstances described in Section 9.B.v.1 of this permit. The submission must contain a description of the noncompliance or emergency, or remedial response and its cause; the period of noncompliance, emergency, or remedial response, including exact dates and times, and, if the noncompliance has not been corrected, the anticipated time it is expected to continue as well as actions taken to implement appropriate protocols outlined in

the *ERRP* (permit application Section 4.1, Attachment A-1); and steps taken or planned to reduce, eliminate and prevent recurrence of the noncompliance or emergency or condition requiring remedial response.

vi. Written Notice

The Permittee shall notify the Administrator, in writing, thirty (30) days in advance of:

1. Any planned well workover;
2. Any planned stimulation activities, other than stimulation for formation testing conducted under WWQR Chapter 24 Section 17; and
3. Any other planned test of the injection well conducted by the Permittee.

vii. The Permittee shall submit a written report to the Administrator of all remedial work concerning the failure of equipment or operational procedures that resulted in a violation of a permit condition at the completion of the remedial work.

viii. For any aborted or curtailed operation, the Permittee shall submit to the Administrator a complete report within thirty (30) days of complete termination of the discharge or associated activities.

ix. Compliance Schedules – Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit must be submitted in an electronic format as approved by the Administrator by the Permittee no later than thirty (30) days following each schedule date. The Permittee shall submit progress reports no later than thirty (30) days following each interim date and the final date of compliance.

x. Other Noncompliance – The Permittee must report all other instances of noncompliance not otherwise reported within the next monitoring report. The reports must contain the information listed in Section 9.B.v.1 of this permit.

xi. Report on permit Review – Within thirty (30) days of receipt of this permit, the Permittee must certify to the Administrator that he or she has read and is personally familiar with all terms and conditions of this permit.

## C. RECORDKEEPING

i. The Permittee must retain records and all monitoring records as identified in Table 10.

ii. Records of monitoring information must include:

1. The date, exact place, and time of sampling or measurements;
2. The name(s) of the individual(s) who performed the sampling or measurements;
3. A precise description of both sampling methodology and the handling of samples;
4. The date(s) analyses were performed;
5. The name(s) of the individual(s) who performed the analyses;
6. The analytical techniques or methods used; and
7. The results of such analyses.

iii. The Permittee must deliver the records to the Administrator at the conclusion of the retention period.

## D. INJECTION FEE SCHEDULE

i. Once injections begin, the Permittee shall pay a fee into the geologic sequestration special revenue account in accordance with WWQR Chapter 29, Section 4. Payment into the special revenue account terminates once injections cease and the injection well is plugged and abandoned.

ii. Failure to pay fees is a violation of WWQR Chapter 29 and may be cause for the revocation of this Class VI permit.

iii. Notice and payment of fees shall be done in accordance with WWQR Chapter 29, Section 4.

## SECTION 10. POST-INJECTION SITE CARE AND SITE CLOSURE

The Permittee must maintain and comply with the approved *PISC and Site Closure Plan* (permit application Section 4.6, Attachment A-1) and must comply with the requirements of WWQR Chapter 24 Section 24. The PISC period is the length of time anticipated to demonstrate that the $CO_2$ injection poses no threat to USDWs and is an enforceable condition of this permit.

i. The *PISC and Site Closure Plan* shall include the information pursuant to WWQR Chapter 24 Section 24(a)(ii) – (iii).

ii. Upon cessation of injection, the Permittee shall either submit an amended *PISC and Site Closure Plan* or demonstrate to the Administrator through monitoring data and modeling results that no amendment to the plan is needed. Any amendments to the *PISC and Site Closure Plan* shall be subject to the provisions identified in WWQR Chapter 24 Section 24(a)(iv)(A) – (C).

iii. The Permittee may amend the *PISC and Site Closure Plan* during the life of the project. The Permittee shall re-submit the *PISC and Site Closure Plan* for the Administrator's approval within thirty (30) days of amending the plan. Once approved, the *PISC and Site Closure Plan* is amended to the permit. Upon receipt of the Administrator's approval, the Permittee shall submit the proposed cost estimate for measurement, monitoring, and verification of the plume stabilization.

iv. Any amendments to the *PISC and Site Closure Plan* must be approved by the Administrator and must be incorporated into the permit and are subject to the permit modification requirements of WWQR Chapter 24 Section 6.

v. PISC shall continue for a period that meets the criteria of W.S. §35-11-313(f)(vi)(F).

vi. The Permittee shall continue to conduct monitoring as specified in the Administrator-approved *PISC and Site Closure Plan* until the Administrator certifies site closure pursuant to WWQR Chapter 24 Section 24(b)(iii).

vii. Prior to certification of site closure, the Permittee shall demonstrate to the Administrator, based on monitoring, other site-specific data, and modeling that is reasonably consistent with site performance, that no additional monitoring is needed to ensure the geologic sequestration project does not and is not expected to endanger a USDW or otherwise threaten human health, safety, or the environment. In addition, the Permittee shall demonstrate, based on the best available understanding of the site, including monitoring data and modeling, that all other site closure standards and requirements have been met.

viii. If the Permittee cannot demonstrate that the requirements of WWQR Chapter 24 Section 24(b)(iii) have been met, the Permittee shall continue post-injection site care.

ix. The Permittee shall notify the Administrator, in writing, at least one hundred and twenty (120) days before filing a request for site closure. At that time, if any changes have been made to the original PISC and Site Closure Plan, the Permittee shall also provide the revised plan.

x. After the Administrator has certified site closure, the Permittee shall plug monitoring wells in a manner approved by the Administrator that will not allow the movement of injection or formation fluids. The Permittee must also restore the site to its pre-injection condition.

xi. The Permittee shall submit a site closure report within ninety (90) days after completion of all closure operations. The report must include all information specified in WWQR Chapter 24 Section 24(d)(i) – (v).

xii. The Permittee shall submit a proposed cost estimate with the site closure report as specified in WWQR Chapter 24 Section 26(i).

xiii. If the Director determines that there are insufficient monies available in the special revenue account, including accumulated interest, based on the cost estimate submitted for the Administrator's evaluation, the Permittee shall make additional payments into the special revenue account to ensure that the sufficient funds are available to execute the required activities identified by W.S. § 35-11-320(c).

xiv. The Permittee shall record a notation on the deed of the facility property or any other document that is normally examined during the title search that will in perpetuity provide any potential purchaser of the property and shall file an affidavit in accordance with W.S. § 35-1-313(f)(vi)(G) that includes the information specified in WWQR Chapter 24 Section 24(e)(i) – (iii).

xv. The site closure report required by WWQR Chapter 24 Section 24 and any PISC data (including data and information used to establish the PISC time frame) shall be retained for ten (10) years following site closure.

xvi. The Permittee must deliver the records to the Administrator at the conclusion of the retention period.

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# TABLES

**TABLE 1. NOTIFICATION AND REPORTING SUMMARY**

| TASK | FREQUENCY | DUE |
|---|---|---|
| Amended PISC and Site Closure Plan | The Permittee may amend the PISC and Site Closure Plan during the life of the project. | Within thirty (30) days of amending the plan. |
| Amended Plans or Demonstrations | Within one (1) year of an AoR reevaluation; following any significant changes to the facility, such as the addition of monitoring wells or newly permitted injection wells within the AoR; or when required by the Administrator. | Submitted within one (1) year of an AoR reevaluation or within Thirty (30) days of any significant changes to the facility or required by the Administrator. |
| Amend Testing and Monitoring Plan | Every five (5) years. | January 30th every five (5) years. |
| AoR Re-evaluation | Not to exceed two (2) years during the **operational life** of the facility or five (5) years **during the PISC period (until site closure)** as specified in the AoR and CAP, or when monitoring and operations conditions warrant. | January 30th every two (2) years during operational life.<br>January 30th every five (5) years during the PISC period until site closure. |
| Compliance Schedules and Progress Reports | Compliance Schedules – Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit. | No later than thirty (30) days following each interim date and the final date of compliance. |
| Financial Assurance Cost Estimate Update | Annual cost estimate update. | Within thirty (30) days of the anniversary date when the original financial assurance cost estimate was submitted. |
| Financial Assurance Adjustment for Inflation | Annual inflation adjustment. | Within sixty (60) days prior to the anniversary date of the establishment of the financial instruments used. |
| Financial Assurance update – cost estimate | Whenever the owner or operator amends the AoR and CAP, the injection well-plugging plan, the PISC and site closure plan, the ERRP, mitigation costs or reclamation costs. | Within sixty (60) days after notice of any amendment. |
| Financial Assurance Update – AoR or CAP Modification | Revise the cost estimate after the Administrator has approved the request to modify the AoR or CAP. | Within sixty (60) days after notice of Administrator approval. |
| Financial Assurance Update – Any Increase in Financial Assurance Cost Estimate | Whenever the financial assurance cost estimate increases to an amount greater than the face amount of the current financial assurance, the Permittee shall either cause the face amount to be increased or an amount at least equal to the current financial assurance cost estimate and submit evidence of such increase to the Administrator, or the Permittee shall obtain other financial responsibility instruments to cover the increase. | Within sixty (60) days after the increase. |
| Financial Assurance – Notice of Cancellation | Upon notice of cancellation, the Permittee shall provide to the Director an alternate financial responsibility demonstration that meets the requirements of WWQR Chapter 24 Section 26(c) – (g). | Within sixty (60) days after notice of cancellation. |
| Financial Assurance – Bankruptcy | In the event of bankruptcy, the owner or operator shall notify the Director by certified mail of the commencement of a voluntary or involuntary proceeding under Title 11 (Bankruptcy), U.S Code, naming the owner or operator of the third-party provider of a financial responsibility instrument as debtor. | Within 10 days after the commencement of proceedings. |
| Oral Notification | If an automatic shutdown is triggered or a loss of mechanical integrity is discovered. | Within twenty-four (24) hours. |
| Oral Notification | Any monitoring data or other information indicates that any contaminant, including corrosion or precipitation of minerals, the injected $CO_2$ stream, displaced formation fluids, or associated pressure front may endanger a USDW or threaten human health, safety, or the environment. | Within twenty-four (24) hours. |
| Oral Notification | Any noncompliance with a permit condition or a requirement of WWQR Chapter 24 that may cause fluid migration into or between USDWs, and malfunction of the injection system that may cause fluid migration into or between USDWs or any excursion. | Within twenty-four (24) hours. |
| Schedule | Prior to pre-operational testing activities. | At least thirty (30) days prior to conducting the first test and submit any changes to the schedule thirty (30) days prior to the next scheduled test. |
| Written Notification | Transfer of Permits – Transfer of a permit is allowed only upon approval by the Director. The proposed permit transferee shall apply in writing as though that person were the original applicant of the permit, and the proposed permit transferee shall agree to be bound by all of the terms and conditions of the permit. | At least forty-five (45) days prior to transfer. |
| Written Notification | Discovery of an excursion. | Within thirty (30) days of discovering the excursion. |
| Written Notification | Prior to plugging a well. | At least sixty (60) days before plugging a well. |
| Written Notification | Any planned well workover; Any planned stimulation activities, other than stimulation for formation testing conducted under WWQR Chapter 24 Section 17; and Any other planned test of the injection well conducted by the Permittee. | At least thirty (30) days in advance of the activity. |

| TASK | FREQUENCY | DUE |
|---|---|---|
| Written Notification | Intent to close the site. | At least one hundred and twenty (120) days before filing a request for site closure. |
| Written Report – Annual | Annually. | January 30th annually. |
| Written Report – Annual Pressure Fall Off Test | Following Annual Pressure Fall off Test. | Report submitted within thirty (30) days of test completion or with the next quarterly monitoring reports, whichever comes first. |
| Written Report – Semi-annual | Thirty (30) days following the end of the period covered in the report. | Semiannual Reports are due on or before July 31st for the first reporting period and January 31st for the second reporting period. |
| Written Report – Quarterly Monitoring | Quarterly. | February 14 (4th quarter of the previous year).<br>May 14 (1st Quarter).<br>August 14 (2nd Quarter).<br>November 14 (3rd Quarter). |
| Written Report – Quarterly Seismicity Record | All seismicity recorded by the seismograph occurring with a radius between 5 km and approximately 80 km within the well location shall be recorded and reported to WDEQ on a quarterly basis. | February 14 (4th quarter of the previous year).<br>May 14 (1st Quarter).<br>August 14 (2nd Quarter).<br>November 14 (3rd Quarter). |
| Written Report – Non-Compliance | Corresponding reporting period. | February 14 (4th quarter of the previous year).<br>May 14 (1st Quarter).<br>August 14 (2nd Quarter).<br>November 14 (3rd Quarter). |
| Written Report – Plugging and Abandonment | Conclusion of plugging and abandonment activities. | Within sixty (60) days after completion of plugging and abandonment of a well. |
| Written Report –MIT | **Proposed Wells** – **Part I and Part II** every five (5) years after construction for first ten (10) years after completion, then every three (3) years after that. If casing liners are installed, a Part I MIT will be conducted on annual basis **Part I** – after any well workover activities. | Report submitted within thirty (30) days of test completion or with the next quarterly monitoring reports, whichever comes first. |
| Written Report – SRT | One-Time per well; the Step-Rate Test is to be conducted within one (1) year of permit authorization or at the time of well completion and prior to injection followed by a report of the test. | Within thirty (30) days of test completion. |
| Written Report – Final Construction Report | Based on construction completion of the injection or monitoring well(s). Includes As-Builts for all injection and monitoring well(s). | Within thirty (30) days after completion of any of the permitted injections or monitoring well(s) or with the next quarterly report, whichever is later. |
| Written Report – Site Closure | Following site closure activities. | Within ninety (90) days after completion of all closure operations. |
| Written Report | Any evidence that the injected $CO_2$ stream or associated pressure front may cause an endangerment to a USDW; Any noncompliance with a permit condition or malfunction of the injection system, which may cause fluid migration into or between USDWs; Any triggering of a shut-off system, either down-hole or at the surface; Ay release of $CO_2$ to the atmosphere or biosphere indicated by the surface air or soil gas monitoring or other monitoring technologies required by WWQR Chapter 24 Section 20(b)(ix); and Any failure to maintain mechanical integrity. | Within twenty-four (24) hours of the identified event. |
| Written Report | Any monitoring data or other information indicate that any contaminant, including corrosion or precipitation of minerals, the injected $CO_2$ stream, displaced formation fluids, or associated pressure front may endanger a USDW or threaten human health, safety, or the environment. | Within five (5) days of discovering the condition. |
| Written Report | Any noncompliance with a permit condition or a requirement of WWQR Chapter 24 that may cause fluid migration into or between USDWs, and malfunction of the injection system that may cause fluid migration into or between USDWs or any excursion. | Within five (5) days of discovering the condition. |
| Written Report | As needed after any failure of equipment or operational procedures that resulted in a violation of a permit condition and resulted in remedial well work. | Within thirty (30) days of the completion of any remedial work. |
| Written Report | Following any aborted or curtailed operation. | Within thirty (30) days of complete termination of the discharge or associated activities. |
| Written Report | Periodic test of mechanical integrity; Any other test of the injection well conducted by the Permittee if required by the Administrator; and any well workover. | Within thirty (30) days of test completion or with the next quarterly monitoring reports, whichever comes first. |

**TABLE 2. FINANCIAL ASSURANCE COMPONENTS AND COST ESTIMATES**

| Financial Responsibility Element | Cost Estimate | Financial Assurance Required/When Funded | Financial Assurance Instrument |
|---|---|---|---|
| A. Corrective Action on other wells in the area of review that require corrective action under WWQR Chapter 24, Section 13 | $0 | No | N/A |
| B. Injection Well Plugging and Abandonment that meets the requirements of WWQR Chapter 24, Section 23. | $597,000 | Yes, Prior to well Permit to Construct Issuance | *WWQR Chapter 24, Section 26(c):*<br>(i) Irrevocable Trust Funds with government-backed securities, or<br>(ii) Surety Bonds, or<br>(iii)Irrevocable Letter of Credit, or<br>(iv)Cash, or<br>(v) Federally Insured Certificates of Deposit. |
| C. Testing and monitoring that meets the requirements of WWQR Chapter 24, Section 20 | $4,365,330 (for 15 years) | No | N/A |
| D. PISC and Site Closure that meets the requirements of WWQR Chapter 24, Section 24 | $15,771,505 | Yes, Prior to Authorization to Inject | *WWQR Chapter 24, Section 26(c):*<br>(i) Irrevocable Trust Funds with government-backed securities, or<br>(ii) Surety Bonds, or<br>(iii)Irrevocable Letter of Credit, or<br>(iv)Cash, or<br>(v) Federally Insured Certificates of Deposit. |
| E. PISC and Site Closure – Monitor Well Plugging | $522,000 | Yes, Prior to Permit to Construct | |
| F. ERR | $5,800,553 | Yes, Prior to Authorization to Inject | *WWQR Chapter 24, Section 26(c):*<br>(i) Irrevocable Trust Funds with government-backed securities, or<br>(ii) Surety Bonds, or<br>(iii)Irrevocable Letter of Credit, or<br>(iv)Cash, or<br>Federally Insured Certificates of Deposit.<br><br>The Permittee may also cover this as part of the Public Liability Insurance *WWQR Chapter 24, Section 26(l)* |

Note: Per WWQR Chapter 24 Section 26(b)(viii), the Permittee shall submit updated financial assurance cost estimates annually. The amounts shown in these Tables are subject to change based on the annual financial assurance updates.
N/A – Not Applicable

## TABLE 3. WWQR CHAPTER 8 USE SUITABILITY CONSITUENT PARAMETERS

| Constituent or Parameter | Chemical Abstracts Service Number | Lab Method |
|---|---|---|
| Aluminum | 7429-90-5 | 200.7 or 200.8 |
| Ammonia | 7664-41-7 | 350.1 |
| Arsenic | 7440-38-2 | 200.7 or 200.8 |
| Barium | 7440-39-3 | 200.7 or 200.8 |
| Beryllium | 7440-41-7 | 200.7 or 200.8 |
| Boron | 7440-42-8 | 200.7 or 200.8 |
| Cadmium | 7440-43-9 | 200.7 or 200.8 |
| Chloride | 16887-00-6 | 300.0 |
| Chromium | 7440-47-3 | 200.7 or 200.8 |
| Cobalt | 7440-48-4 | 200.7 or 200.8 |
| Copper | 7440-50-8 | 200.7 or 200.8 |
| Cyanide | 57-12-5 | 335.4 |
| Fluoride | 7782-41-4 | A4500-F C |
| Hydrogen Sulfide | 7783-06-4 | A4500-S D |
| Iron | 7439-89-6 | 200.7 or 200.8 |
| Lead | 7439-92-1 | 200.7 or 200.8 |
| Lithium | 7439-93-2 | 200.7 or 200.8 |
| Manganese | 7439-96-5 | 200.7 or 200.8 |
| Mercury | 7439-97-6 | 245.1 |
| Nickel | 7440-02-0 | 200.7 or 200.8 |
| Nitrate | 14797-55-8 | 323.2 |
| Nitrite | 14797-65-0 | A4500-NO2 B |
| Nitrate + Nitrite | --- | 353.2 |
| Oil & Grease | --- | 1664A |
| Phenols | 108-95-2 | 420.1 or 420.4 |
| Selenium | 7782-49-2 | 200.7 or 200.8 |
| Silver | 7440-22-4 | 200.7 or 200.8 |
| Sulfate | 14808-79-8 | 300.0 or SM4110 B |
| Total Dissolved Solids | --- | 2540C |
| Vanadium | 7440-62-2 | 200.7 or 200.8 |
| Zinc | 7440-66-6 | 200.7 or 200.8 |
| pH | --- | 150.1 or SM4500H+B |
| Radium 226 and Radium 228 | --- | A7500-RA |
| Total Strontium 90 | 10098-97-2 | 905.0 |
| Gross alpha particle radioactivity (including Radium 226 but excluding Radon and Uranium) | 12587-46-1 | 900.1 |

## TABLE 4. INORGANIC CONSTITUENTS

| Constituent or Parameter | Chemical Abstracts Service Number | Lab Method |
|---|---|---|
| Bicarbonate | 144-55-8 | A2320B |
| Bromide | 24959-67-9 | 300.0 or SM4500-$Br^-$ |
| Carbonate | 471-34-1 | A2320B |
| Chloride | 16887-00-6 | 300.0 |
| Iodide | 20461-54-5 | 300.0 or SM4500-$I^-$ |
| Calcium | 7440-70-2 | 200.7 or SM3500-Ca |
| Magnesium | 7439-95-4 | 200.7 or SM3500-Mg |
| Potassium | 7440-09-7 | 200.7 or SM3500-K |
| Sodium | 7440-23-5 | 200.7 or SM3500-Na |
| Sulfate | 14808-79-8 | 300.0 or SM4110 B |

## TABLE 5. GENERAL PHYSICAL PARAMETERS

| Constituent or Parameter | Chemical Abstracts Service Number | Lab Method |
|---|---|---|
| Temperature in degrees Fahrenheit ($^oF$) | --- | SM2550 B |
| Turbidity | --- | SM2130 |
| pH | --- | SM4500$H^+$ B |
| Specific Conductance at 25 degrees Celsius ($^oC$) | --- | SM2510 B |
| Specific Gravity | --- | D1429 |
| Alkalinity | --- | SM2320 B |

**TABLE 6. MAXIMUM INJECTION RATES, ANNULUS PRESSURES, AND LIMITING SURFACE INJECTION PRESSURES**

| Parameter | Spirea I-1 |
|---|---|
| Maximum Injection Rate (bbl/d) | TBD |
| Maximum Injection Rate gallons per minute(gpm) | TBD |
| Maximum Annulus Pressure (pounds per square inch gage (psig)) | TBD (based on Injection Pressure) |
| Minimum Annulus Pressure (psig) | TBD (based on Injection Pressure) |
| Estimated Fracture Gradient, *F* (pounds per square inch per foot (psi/ft)) | TBD |
| Fracture Pressure, $P_f = F \cdot D_p$ | TBD |
| Depth to Top of Formation, $D_p$ (ft-bgs) | TBD |
| Temperature at Mid-Point of Perforations (°F) | TBD |
| Maximum TDS of Injectate (mg/L) | TBD |
| Density of Injectate, $\rho_j$ (grams per cubic centimeter (g/cm$^3$)) | TBD |
| Injectate Fluid Gradient (psi/ft) $grad_j = \rho_j \cdot 12\frac{in}{ft} \cdot 16.387\frac{cm^3}{in^3} / 453.592\ \frac{g}{lb}$ | TBD |
| Hydrostatic Pressure (psi) $P_h = D_p \cdot grad_j$ | TBD |
| Tubing Length, $T_L$ (ft) | TBD |
| Tubing Inside Diameter, *d* (inches (in)) | TBD |
| Tubing Friction Loss Factor, *T* (psi/1000 ft) | TBD |
| Average Injection rate, *q* (gpm) | TBD |
| Pressure Loss due to Tubing Friction (psi/ft) $P_d = (4.52q^{1.85})/(\boldsymbol{c}^{1.85}d^{4.8655})$ | TBD |
| Total Pressure Loss from Tubing Friction (pounds per square inch(psi)) $P_L = P_d \cdot\cdot\ T_L$ | TBD |
| $SIP = P_f - P_h + P_L$ (psig) | TBD |
| $LSIP = 0.9 \cdot SIP$ (psig) | TBD |

Notes:

***c*** - Hazen-Williams design coefficient for lined stainless-steel piping, 145. This value is considered conservative and the Permittee may propose an alternate coefficient value for use.

bbl/d – Barrels per day (standard barrel equal to 42 gallons)

in$^3$ – cubic inches

lb – pound

LSIP – Limiting Surface Injection Pressure

SIP – Surface Injection Pressure

TBD – To Be Determined

## TABLE 7. INJECTATE ANALYSIS

| Schedule | Parameter Analyzed | Composition | Composition | Method |
|---|---|---|---|---|
| Quarterly | $CO_2$ | ppmv | mol% | Gas Chromatography |
| | Ethane | ppmv | mol% | Gas Chromatography |
| | Propane | ppmv | mol% | Gas Chromatography |
| | n-Butane | ppmv | mol% | Gas Chromatography |
| | Hydrogen | ppmv | mol% | Gas Chromatography |
| | Nitrogen | ppmv | mol% | Gas Chromatography |
| | Methane | ppmv | mol% | Gas Chromatography |
| | Oxygen | ppmv | mol% | Gas Chromatography |
| | Water | ppmv | mol% | Gas Chromatography |
| | Temperature | °C | - | 2250 B |

Note:
ppmv – Parts Per Million Per Volume
mol% - Mole percent is the percentage that the moles of a particular component are of the total moles that are in a mixture.

## TABLE 8. MONITOR WELL ANALYSIS

| Schedule | Parameter Analyzed | Units | EPA Method | Standard Method |
|---|---|---|---|---|
| Quarterly | $CO_2$ | ppmv | 3C | GC, modified ASTM 1945D |
| | pH | s.u. | 150.1 or 150.2 | 4500-H+B |
| | Conductivity | µmhos/cm | 120.1 | 2510 B |
| | Alkalinity | mg/L | 310.2 | 2320 B |
| | TDS | mg/L | 160.1 | 2540 C |

Note:
µmhos/cm - Micromhos per centimeter
s.u. – standard unit

## TABLE 9. MONITORING FREQUENCY

| Monitoring Parameter | Frequency | Measurement Method |
|---|---|---|
| Injection rate (gpm) | Continuous | digital recorder |
| Daily Injection Volume (gallons (gal)) | Daily | digital totalizer |
| Total Cumulative Volume (gal) | Continuous | digital totalizer |
| Well head injection pressure (psig) | Continuous | digital recorder |
| Annular pressure (psig) | Continuous | digital recorder |
| Injection fluid temperature ($^oF$) | Continuous | digital recorder |
| Injectate Analysis (**See Table 7**) | Quarterly | Injectate Grab Sample |
| Groundwater Sample Above Upper Confining Zone **(See Table 8**) | Quarterly | Monitor Well Sample |
| Annulus Fluid Volume Added (gal) | When added | Measurement |
| Corrosion Monitoring of Well Materials | Quarterly | Method in Testing and Monitoring Plan |

## TABLE 10. RECORD RETENTION SCHEDULE

| RECORD | RETENTION PERIOD |
|---|---|
| Calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for the permit. | For a period of at least three (3) years from the date of the sample, measurement, report, or application. This period may be extended by request of the Administrator at any time; |
| The nature and composition of all injected fluids. | Until ten (10) years after the completion of any plugging and abandonment procedures under WWQR Chapter 24 Section 23. |
| All modeling inputs and data used to support AoR re-evaluations under WWQR Chapter 24 Section 13. | Retained for ten (10) years. |
| Well plugging report required by WWQR Chapter 24 Section 23, the site closure report required by Section 24, and any PISC data (including data and information used to establish the PISC time frame). | Retained for ten (10) years following site closure. |
| All data used to complete permit applications. | Retained for the life of the geologic sequestration project and for ten (10) years following site closure. |
| All other monitoring records required by a permit. | Retained for a period of ten (10) years following site closure. |
| The Permittee shall maintain in its records a current map of the access route(s) to the facility and contact information for the owners or agents of all properties that must be crossed to access the facility. The Permittee shall ensure that the documentation, map, and contact information are current at all times. The Permittee shall provide the documentation, map, and contact information to WDEQ personnel upon request. | On closure of a facility, the Permittee shall maintain such records for a period of three (3) years. |

## TABLE 11. REQUIRED LOGS AND ANALYSIS DURING DRILLING AND COMPLETION

| Required Log/Analysis | Timing of Log/Analysis |
|---|---|
| Deviation Checks | While Drilling/When Collected |
| Whole/Sidewall Core Analysis | |
| Resistivity | Before and Upon Installation of Surface Casing |
| Spontaneous Potential | |
| Caliper | |
| Cement Bond and Variable Density Log (Section 6.C.iv.4) | |
| Resistivity | Before and Upon Installation of Long String Casing |
| Spontaneous Potential | |
| Porosity | |
| Caliper | |
| Gamma Ray | |
| Fracture Finder Log | |
| Cement Bond and Variable Density Log (Section 6.C.iv.4) | |
| Formation Fluid Samples (Section 6.C.iv.5) | Upon Well Completion |
| Part I MIT (Section 6.C.iv.6) | |
| Part II MIT (Section 6.C.iv.6) | |

## ATTACHMENTS

These attachments include but are not limited to, permit conditions and plans concerning operating procedures, monitoring, and reporting, in compliance with the WEQA, W.S. §§ 35-11-101 through 1104, specifically 301(a)(i) through 301 (a)(iv), Laws 1973, Ch. 250, Section 1), (W.S. § 31-11-313, Laws 2008, Ch. 30, Section 1), and WWQR, Chapters 24 and 29. The Permittee must comply with these conditions and adhere to these plans as they are approved by the Administrator by their incorporation into this permit. Furthermore, attachments include all information used in consideration of the review and issuance of this permit.

## ATTACHMENT A-1: Permit Application Dated December 21, 2023

| | |
|---|---|
| Facility Name: | Eastern Wyoming Sequestration Hub, Spirea I-1 |
| Facility Address: | SW1/4 NW1/4 Section 34 T13N R63W |
| Well Location: | 41.052367, -104.424469 (Spirea I-1) |
| Monitoring Well Location: | 41.0510846, -104.425528 (Spirea M-1 as proposed) |

The Permittee must comply with these conditions and adhere to these plans as they are approved by the Administrator by their incorporation into this permit.

- Section 3.0 Area of Review
- Section 4.1 Emergency and Remedial Response Plan
- Section 4.2 Financial Assurance Demonstration Plan
- Section 4.3 Testing and Monitoring Plan
- Section 4.4 Well Casing and Cementing Program
- Section 4.5 Plugging Plan
- Section 4.6 Postinjection Site Care and Site Closure Plan
- Section 5.0 Injection Well Operations

21 December 2023

Ms. Lily Barkau, P.G.
Groundwater Section Manager
Wyoming Department of Environmental Quality
Water Quality Division
200 West 17th Street, 2nd Floor
Cheyenne, WY 82002

*Submitted electronically:* WDEQ Water Quality Division Document Uploads (smartsheet.com) .

Dear Ms. Barkau:

Tallgrass High Plains Carbon Storage, LLC. has submitted the Spirea I-1 Class VI UIC to a secure SharePoint: https://tallgrassenergylp.sharepoint.com/:b:/r/sites/HighPlains-WDEQ/Shared%20Documents/General/Spirea%20I-1/_Trailblazer%20Class%20VI%20application_Spirea_I-1-20231221.pdf?csf=1&web=1&e=dZBQU4 . High Plains looks forward to your correspondence on this permit.

Kind Regards,

Katy Larson
Geoscience Compliance Manager
Tallgrass Energy Partners, LP

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# GEOLOGIC SEQUESTRATION

# PERMIT APPLICATION (Form 1)

## GENERAL INFORMATION AND SIGNATORY AUTHORITY

The geologic sequestration permit application consists of two parts: (1) General Information and Signatory Authority and (2) Technical Information. All sections are to be completed in order to obtain the permit to construct. Operation of a Class VI well is not authorized until authorization to inject is received from the Department. During the construction of the Class VI well, information collected may warrant a permit modification. Only sections pertaining to the modification are required to be completed and public notice requirements will only pertain to those sections being modified. **A pre-application meeting is required prior to this application being submitted.**

**Application Type**

| | | |
|---|---|---|
| UIC Class I Conversion | ☐ | UIC Class I Permit Number: |
| UIC Class II Conversion | ☐ | Hearing Number Recommending Transfer: |
| UIC Class V Conversion | ☐ | UIC Class V Permit Number: |
| New UIC Class VI | ☑ | |
| *UIC Class VI Modification | ☐ | UIC Class VI Permit Number: 2023-041 |

*For Class VI permit modifications, only the sections requiring a modification should be completed. Permit modifications require the signature of the responsible corporate officer as well as the licensed geologist, or licensed engineer, if applicable.

**Public Notice**

In accordance with W.S. 35-11-313(f)(ii)(N), the applicant shall provide notice of the application for the geologic sequestration project proposed. Proof of notice is required to surface owners, mineral claimants, mineral owners, lessees, and other owners of record of subsurface interests that are located within one (1) mile of the proposed boundary of the geologic sequestration site. The publishing of notice of the application is required in a newspaper of general circulation in each county of the proposed operation at weekly intervals for four (4) consecutive weeks. **An affidavit of the notice shall be submitted to WDEQ. Publishing of the notice may not occur more than 14 days following the submission of the permit application.**

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## Wyoming Conservation Executive Orders 2019-3 and 2020-1

### a. Sage Grouse

Pursuant to the requirements of the Governor's Executive Order 2019-3 (SGEO), applicants for new UIC permits must determine if any part of the project falls within a Greater Sage-Grouse Core Area (SGCA) before applying. If any part of the project falls within an SGCA, the first point of contact for addressing sage-grouse issues is the Wyoming Game and Fish Department (WGFD). Please coordinate with the WGFD and obtain written confirmation of consistency with the Executive Order prior to applying for a UIC permit and submit this documentation as part of the application package. For more information, contact the Wyoming Game and Fish: Wyoming Game and Fish Department Habitat Protection Program (307) 777-4506 or wgfd.hpp@wyo.gov.
Note that the application shall be returned without processing until a letter confirming consistency with the Executive Order has been obtained. Additional information and maps of SGCAs are available at https://wgfd.wyo.gov/Habitat/Sage-Grouse-Management.

Check one of the following, as applicable to the project:

☐ Some part, or all, of my project falls within an SGCA and I have contacted the WGFD for a SGEO review. A letter from the WGFD confirming consistency with the Executive Order is attached.

☐ Some part, or all, of my project falls within an SGCA and I have contacted the WGFD for a SGEO review. It does not comply with the SGEO. I have valid and existing rights related to this permit. I have committed to the following recommendations that will minimize the impact on the sage grouse.

☑ By checking this box, I certify that I have reviewed the SGCAs available online, and determined that no portion of my project falls within an SGCA. *(No additional requirements apply.)*

### b. Migration Corridors.

Pursuant to the requirements of the Governor's Executive Order 2020-1, applicants for new UIC permits must determine if any part of the project falls within a Migration Corridor designated under the Executive Order before applying. If any part of the project falls within a Migration Corridor, you must consult with the WGFD. Please coordinate with the WGFD and obtain written confirmation of consistency with the Executive Order prior to applying for a UIC permit and submit this documentation as part of the application package. For more information, contact the Wyoming Game and Fish: Wyoming Game and Fish Department Habitat Protection Program (307) 777-4506 or wgfd.hpp@wyo.gov.
Note that the application shall be returned without processing until a letter confirming consistency with the Executive Order has been obtained. Please also visit the WGFD's Management Page for more information and a map of the currently designated Migration Corridors: https://sites.google.com/view/wywildlifemigrationadvisorygrp/home?fbclid=IwAR3y_HEQxOo4HckAVKzRzT5kdLaOsyiV0vt9NJOtzNu45b_WK0vESwTWVzY#h.bc90kvcpohnu.

Check one of the following, as applicable to the project:

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☐ Some part, or all, of my project falls within the area described and I have contacted the WGFD for consultation. A letter from the WGFD confirming consistency with the Executive Order is attached.

☑ By checking this box, I certify that I have reviewed the Migration Corridors information available online, and determined that no portion of my project falls within a Migration Corridor. *(No additional requirements apply.)*

**1. General Information**

| | | | |
|---|---|---|---|
| Carbon Sequestration Project Name: Eastern Wyoming Sequestration Hub | | | |
| Owner/Operator Name Tallgrass High Plains Carbon Storage, LLC | | | |
| Responsible Corporate Officer Kyle Quackenbush | | Title Segment President & Vice President-Liquids (Crude Oil & CO2) | |
| Telephone Number 303-763-3319 | Email Address kyle.quackenbush@tallgrass.com | | |
| Owner/Operator Address 4200 West 115th Street | City Leawood | State KS | Zip 66211 |

| | | | |
|---|---|---|---|
| Facility Location Address (if different than Operator Address) | City | State | Zip |
| Telephone Number | | | |
| Facility Mailing Address (if different than Operator Address) | City | State | Zip |
| Telephone Number | | | |

| | | | |
|---|---|---|---|
| Consultant Name Numeric Solutions, LLC | Primary Contact Name Eric White | | |
| Consultant Address 1536 Eastman Ave Ste D | City Ventura | State CA | Zip 93003 |
| Telephone Number 805-794-5011 | Email Address eric.white@numericsolutions.com | | |
| May they be contacted directly? ☑ Yes ☐ No | | | |

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**2. Site and Facility Description**

A description of the proposed geologic sequestration facility and documentation sufficient to demonstrate that the applicant has all legal rights, including but not limited to the right to surface use, necessary to sequester carbon dioxide and associated constituents into the proposed geologic sequestration site.

| |
|---|
| The proposed Eastern Wyoming Sequestration Hub (EWS Hub) will be located in the southeastern corner of Wyoming, in Laramie County, Section 34, Township 13N, Range 63W. Additional documentation will be provided as available. |

**3. SIC Codes**

| | | |
|---|---|---|
| List in descending order of significance the four (4) digit "Standard Industrial Classification Manual" which best describes your facility in terms of the principal products or services you produce or provide. Also, specify each classification in words. | 1st | Code/Name 4619 - Pipelines, not elsewhere classified |
| | 2nd | Code/Name 4953 - Refuse systems (Nonhazardous water disposal sites) |
| | 3rd | Code/Name |
| | 4th | Code/Name |

**4. Water Quality Management Plan, Wellhead Protection Area, Source Water Protection Area**

| | | |
|---|---|---|
| Is the Geologic Sequestration Project within a state-approved water quality management plan area? | YES ☐ | NO ☑ |
| Is the Geologic Sequestration Project within a state-approved wellhead protection area? | YES ☐ | NO ☑ |
| Is the Geologic Sequestration Project within a state-approved source water protection area? | YES ☐ | NO ☑ |

**5. Mineral and Surface Ownership for Area of Review**

| | | | | | | |
|---|---|---|---|---|---|---|
| Mineral Ownership: | ☐ | Applicant | ☐ | Surface Owner | ☐ | State |
| | ☐ | Fed | Mineral Lease # See technical report | | | |

| | | | | |
|---|---|---|---|---|
| Surface Ownership: | ☐ Applicant | ☐ State | ☐ Fed | ☐ Indian Lands (Contact EPA Region 8) |
| | ☑ Private (Specify) Lease | | | ☐ Other (Specify)_____ |

| |
|---|
| Is the facility located on any historic or archeological site? Yes ☐ No ☑ |

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## 6. Contact Information

The owner or operator shall provide a list of contacts for Tribes on Indian lands within the geologic sequestration project as defined by the Area of Review.

Attach a legal description of land ownership within the Area of Review. List ownership by tract or submit in plat form.

## 7. Access for Inspections

Wyoming Statute (W.S.) 35-11-303 (a) states: "the administrator of the water quality division at the direction of the director: (i) may conduct on-site compliance inspections of all facilities and work during or following the completion of any construction, installation or modification for which a permit is issued under W.S. 35-11-301 (a)(ii)."

As part of its application, the applicant shall certify under penalty of perjury that the applicant has secured and shall maintain permission for WDEQ personnel to access the permitted facility, including (i) permission to access the land where the facility is located, (ii) permission to collect resource data as defined by W.S. § 6-3-414, and (iii) permission to enter and cross all properties necessary to access the facility if the facility cannot be directly accessed from a public road. A map of the access route(s) to the facility shall accompany the application.

> *I,* Kyle Quackenbush *, certify under penalty of perjury that the applicant has secured and shall maintain permission for WDEQ personnel and their invitees to access the permitted facility, including (i) permission to access the land where the facility is located, (ii) permission to collect resource data as defined by Wyoming Statute § 6-3-414, and (iii) permission to enter and cross all properties necessary to access the facility if the facility cannot be directly accessed from a public road.*

## 8. Comments

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**9. Certification**

All applications for permits, reports, or information submitted to the Administrator shall be signed by a responsible corporate officer.

| | | |
|---|---|---|
| "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of a fine and imprisonment for knowing violations." | | |
| Signature DocuSigned by: Kyle Quackenbush 95601045D45742D... | Printed Name Kyle Quackenbush | |
| Title Segment President and VP - Liquids (Crude Oil and CO2) | | Date 12/21/2023 |

**10. Carbon Dioxide Stream Exclusion**

The definition of the "carbon dioxide stream" means carbon dioxide, plus associated substances derived from the source materials and any processing, and any substances added to the stream to enable or improve the injection process. Within Chapter 24, the term "carbon dioxide stream" does not include any carbon dioxide stream that meets the definition of a hazardous waste under 40 CFR 261.3. Any Class VI UIC well owner or operator, who claims that a carbon dioxide stream is excluded under paragraph (h) of 40 CFR 261.4 must have an authorized representative (as defined in WWQR Chapter 24 Section 2(mm)) sign a certification statement worded as follows:

| | | |
|---|---|---|
| "I certify under penalty of law that the carbon dioxide stream that I am claiming to be excluded under 40 CR 261.4(h) has not been mixed with, or otherwise co-injected with, hazardous waste at the UIC Class VI permitted facility, and that injection of the carbon dioxide stream is in compliance with the applicable requirements for UIC Class VI wells, including the applicable requirements in WWQR Chapter 24." | | |
| Signature DocuSigned by: Kyle Quackenbush 95601045D45742D... | Printed Name Kyle Quackenbush | |
| Title Segment President and VP - Liquids (Crude Oil and CO2) | | Date 12/21/2023 |

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# GEOLOGIC SEQUESTRATION

## PERMIT APPLICATION

## TECHNICAL INFORMATION

The geologic sequestration permit application consists of two parts: General Information and Signatory Authority and Technical Information. Operation of a Class VI well is not authorized until authorization to inject is received from the department. During the construction of the Class VI well, information collected may warrant a permit modification. Modifications will only require sections pertaining to the modification to be completed and public notice requirements will only pertain to those sections being modified.

**To expedite the review of the permit application, an application report template is provided.** The following Table of Contents and text identifies the various sections with accompanying figures, tables, and appendices to accompany the application. All sections should be completed. If a section is not applicable, please state such in the document.

If data is not available but will be collected during well construction activities, please incorporate work plans describing the work to be completed where the text indicates as-builts or collected data. After the information is collected during well construction activities, those sections of the permit application may be revised as part of the permit modification to include as-builts and data collected. Additional figures and tables may be incorporated into the document and renamed to reflect site-specific information.

A Word document is provided to assist with completing the document. The italicized text should be deleted and replaced with site-specific information. If you have additional questions or need further clarification, please contact Lily Barkau at (307) 777-7072 or lily.barkau@wyo.gov or Graeme Finley at (307) 473-3478 or graeme.finley@wyo.gov.

# Underground Injection Control

# Carbon Sequestration

# Class VI Permit Application
# Eastern Wyoming Sequestration Hub
# Permit No. 2023-041
# Facility ID No. WYS-021-00155

## DECEMBER 2023


Prepared by:

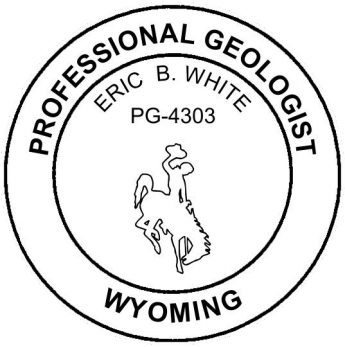
Kyle Quackenbush (Executive Contact)
Katy Larson (UIC Coordinator)
Tallgrass High Plains Carbon Storage, LLC
4200 West 115th Street
Leawood, KS 66211

**Numeric Solutions, LLC**
1536 Eastman Ave., Suite D
Ventura, CA 93003

## CERTIFICATION OF PROFESSIONAL GEOLOGIST

Sections of permit applications that represent geologic work shall be sealed, signed, and dated by a licensed professional geologist as required by W.S. **§33-41-115**.

The geologic interpretations, cross sections, maps, and hydrologic studies that are included in this application were all completed under the responsible charge or direct supervision of the licensee, who has reviewed this work and certifies that it is prepared according to the highest standards of Professional Geology.




| | |
|---|---|
| Eric B. White | |
| Printed Name of Professional Geologist | P.G. Number (SEAL) |
| Eric White | 12/20/2023 |
| Signature of Professional Geologist | Date Signed |

## Certification of Professional Engineer:

Sections of permit applications that represent engineering work shall be sealed, signed, and dated by a licensed professional engineer as required by W.S. **§33-29-601**.

The Engineering Designs, Plans, and Specifications that are included in this application were all completed under the responsible charge or direct supervision of the licensee who has reviewed this work and certifies that it is prepared according to the highest standards of Professional Engineering.




| Ray W. Clanton, PE | |
|---|---|
| Printed Name of Professional Engineer | P.E. Number (SEAL) |
| Ray W Clanton, PE | 12/20/2023 |
| Signature of Professional Engineer | Date Signed |

## LIMITATIONS AND DISCLAIMER

This Class VI permit application has been prepared for the exclusive use of Tallgrass High Plains Carbon Storage, LLC (the "Client") and its representatives as it pertains to Permit Number 2023-041, for well Spirea I-1 as part of Facility ID Number WYS-021-00155, within the Client's Eastern Wyoming Sequestration Hub, Laramie County, Wyoming. Any interpretation of data represents our professional opinions and is based in part on information supplied by the Client and publicly available datasets maintained by the USGS, WYDEQ, WSGS, WSEO, WOGCC, and other federal and state agencies. These opinions and information are based on currently available data and are arrived at in accordance with currently accepted geologic and engineering practices at this time and location.

The data presented in this application are intended only for the purpose, site location, and project indicated. This application is not a definitive study of Laramie County and should not be interpreted as such. The data reported is limited by the scope of the work as defined by the client's request, the time, availability of access to the Site, and information submitted to Numeric Solutions, LLC.

Uncertainties are inherent in the interpretation of geologic and engineering data. Any determination, computation, estimate, evaluation, classification, or categorization made by us represents only our informed professional judgment based on the data and information utilized. There are no representations or guarantees that the sampling points are representative of the entire Lease(s), Area, or field. Data collected by past oil and gas operators of the Area used in this work reflect the conditions at specific locations at a specific point in time. No other interpretations, warranties, or guarantees, expressed or implied, are included or intended in the contents of this transmittal.

As required, all interpretive geologic work was performed under the responsible charge or direct supervision of a licensed Wyoming Professional Geologist as defined in the Wyoming Geologists Practice Act of the Wyoming Professions and Occupations code (Title 33, Ch. 41, §101–121).

In addition, as required, all engineering designs, plans, and specifications were generated under the responsible charge or direct supervision of a licensed Professional Engineer as defined in the Wyoming Engineers and Surveyors Act of the Wyoming Professions and Occupations code (Title 33, Ch. 39, §201–910).

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# ACRONYMS AND ABBREVIATIONS

Note: All terms are written as used in the text.

| | |
|---|---|
| AIFE | American Institute of Formation Evaluation |
| AOI | area of interest |
| AoR | area of review |
| AP | artificial penetration |
| ATSM | American Society for Testing and Materials |
| bbl | barrel(s) |
| Bcf | billion cubic feet |
| bgs | below ground surface |
| BHP | bottomhole pressure |
| BOP | blowout preventer |
| BPV | back-pressure valve |
| CBL | cement bond log |
| CCUS | carbon capture and underground storage |
| CMG | Computer Modelling Group |
| COMB | Colorado Mineral Belt |
| CRA | corrosion resistant alloy |
| DAS | distributed acoustic sensing |
| DIC | dissolved inorganic carbon |
| DOC | dissolved organic carbon |
| DSS | distributed strain sensing |
| DST | drill stem test |
| DTS | distributed temperature sensing |
| EC | electrical conductivity |
| EHS | environmental, health and safety |
| EOS | equation of state |
| EPA | Environmental Protection Agency |
| ERP | Emergency Response Plan |

| | |
|---|---|
| ERRP | Emergency and Remedial Response Plan |
| EWS Hub | Eastern Wyoming Sequestration Hub |
| FADP | Financial Assurance Demonstration Plan |
| FMI | Fullbore Formation Microimager |
| FTIR | Fourier transform infrared spectroscopy |
| GR | gamma ray |
| HAZWOPER | Hazardous Waste Operations and Emergency Response |
| ICP-MS | inductively coupled mass spectrometry |
| IEc | Industrial Economics, Inc. |
| ISA | Impact Study Area |
| ICS | Incident Command System |
| IEA | International Energy Agency |
| ISIP | instant shut-in pressure |
| Krg | relative gas permeability |
| Krw | relative water permeability |
| LOC | loss of containment |
| LCZ | lower confining zone |
| MICP | mercury injection capillary pressure |
| mD | millidarcy(ies) |
| MD | measured depth |
| MDT | Modular Formation Dynamics Tester |
| mg/L | milligrams per liter |
| MIRU | move in and rig up |
| MIT | mechanical integrity test |
| MM | million |
| MMCF/d | million cubic feet per day |
| MT/yr | metric tons per year |
| MMT/yr | million metric tons per year |
| NPDES | National Pollutant Discharge Elimination System |

| | |
|---|---|
| OSHA | Occupational Safety and Health Administration |
| P&A | plugging and abandonment |
| PGA | Peak ground acceleration |
| PISC | post-injection site care |
| ppg | pounds per gallon |
| ppm | parts per million |
| psi | pounds per square inch |
| psig | pounds per square inch gauge |
| RCA | routine core analysis |
| RCRA | Resource Conservation and Recovery Act |
| SCADA | supervisory control and data acquisition |
| $sCO_2$ | supercritical $CO_2$ |
| SFB | synthetic formation brine |
| $SH_{max}$ | maximum horizontal stress |
| $SH_{min}$ | minimum horizontal stress |
| SP | spontaneous potential |
| SG | specific gravity |
| SRT | step-rate test |
| SS | subsea |
| SSTVD | subsea true vertical depth |
| SWD | saltwater disposal well |
| TD | total depth |
| TDS | total dissolved solids |
| TEC | tubing encapsulated conductor |
| TVD | true vertical depth |
| UCZ | upper confining zone |
| UIC | Underground Injection Control |
| USDW | underground source of drinking water |
| USGS | U.S. Geological Survey |

| | |
|---|---|
| UST | underground storage tanks |
| WEA | Wyoming Energy Authority |
| WFT | wireline formation tester |
| WHP | wellhead pressure |
| WOGCC | Wyoming Oil and Gas Conservation Commission |
| WRDS | Water Resources Data System |
| WSEO | Wyoming State Engineer's Office |
| WSGS | Wyoming State Geological Society |
| WWDC | Wyoming Water Development Commission |
| WYDEQ | Wyoming Department of Environmental Quality |
| XRD | X-ray diffraction |
| XRF | X-ray fluorescence |

# 1 PROJECT INFORMATION

According to the International Energy Agency (IEA), 40 million metric tons (MMT) of carbon dioxide ($CO_2$) are captured annually in the world. [1] By 2070, the world will need to capture and store more than 10,000 MMT of $CO_2$ to meet the IEA's Sustainable Development Scenario plan—which makes the need for projects and investment paramount to meeting these climate goals. [2] As part of the Paris Agreement, North America plans to create a carbon pollution-free power sector by 2035. This would require the elimination of approximately five billion metric tons per year by 2035. [3] Tallgrass Energy, L.P. (Tallgrass), headquartered in Leawood, Kansas, is a committed leader at the forefront of the U.S. decarbonization efforts. Tallgrass is a pipeline and gas storage company that enables a high quality of life through the delivery of energy and services that fuel homes and businesses. Tallgrass's subsidiary, Tallgrass High Plains Carbon Storage, LLC (High Plains), was formed to focus on Tallgrass's carbon sequestration efforts. As a demonstration of Tallgrass's decarbonization commitment, the company is developing a sequestration site in Laramie County, Wyoming, known as the Eastern Wyoming Sequestration Hub (EWS Hub). The EWS Hub is an innovative, multi-state decarbonization effort focused on permanently sequestering $CO_2$ from multiple emitters located in Wyoming and several surrounding states. The focus of this permit application is the EWS Hub $CO_2$ sequestration well, Spirea I-1, located in Laramie County.

Tallgrass and predecessor companies have operated natural gas storage fields for more than 70 years. Tallgrass currently operates 90 wells, 74 billion cubic feet (Bcf) of natural gas storage capacity, and 20,470 compression horsepower across the Huntsman and East Cheyenne gas storage fields. These gas storage operations provide Tallgrass with critical subsurface working knowledge and skill sets that transfer directly to the sequestration of $CO_2$, specifically the injection, monitoring, and storage of gaseous fluids in porous reservoirs.

The State of Wyoming previously recognized Tallgrass's commitment to decarbonization when the Wyoming Energy Authority (WEA) awarded Tallgrass's subsidiary a grant to help fund the development of the EWS Hub. The grant is in addition to High Plains' proposed direct investment in the EWS Hub project, designed to provide a cost-effective means of sequestering $CO_2$. "Wyoming is deeply committed to providing decarbonized solutions for the 21st century," said Dr. Glen Murrell, Executive Director of the WEA. "We are pleased to be able to fund Tallgrass' Eastern Wyoming Sequestration Hub project, which has the potential to add an important resource for our net-zero goals." [4]

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[1] https://www.iea.org/reports/about-ccus

[2] https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/

[3] https://www.usgs.gov/faqs/how-much-carbon-dioxide-does-united-states-and-world-emit-each-year-energy-sources

[4] https://tallgrass.com/newsroom/press-releases/tallgrass-to-develop-a-commercial-scale-co2-sequestration-hub-in-wyoming

High Plains proposes drilling and completing a carbon sequestration well in Laramie County. The following application will (1) characterize the geology and reservoir characteristics of the proposed injection well location; (2) describe the engineering design of the injection well; and (3) provide an overview of the operational plans including monitoring, emergency response, and financial assurance. In accordance with all federal and state regulations for Class VI wells, the permit will be updated every two years during active well injection and every five years post-injection.

## 1.1 EWS Hub Key Attributes

The development of the EWS Hub will have significant economic and social benefits for the State of Wyoming, specifically Laramie County. The EWS Hub and its affiliate's transportation of carbon to the EWS Hub will result in more than 626 jobs during the construction phase and approximately 47 jobs during ongoing operations. The construction efforts will result in $32.9 million dollars in wages and $42.1 million in tax revenue during the two-year construction period. Operations will result in an additional $3.5 million in wages and $8.4 million in taxes revenue during the period of operations.

As measured by sales and personal earnings, business activity (i.e., construction contractors, rental equipment providers, restaurants, retail, and other required services) in the area is expected to increase during the construction of the EWS Hub, resulting in tax revenue growth for Laramie and other local municipalities. The EWS Hub will provide significant, temporary economic benefits, both direct and indirect, to the local communities of southeast Wyoming and the state itself during construction. The EWS Hub will provide even greater long-term economic benefits during the full operating life of the project.

The environmental benefits of the EWS Hub will impact not only those local communities and the State of Wyoming but also the global community through reducing greenhouse gas emissions, improving air quality, and helping to slow the rate of climate change. The sequestration of up to 3 MMT/yr of $CO_2$ is equivalent to removing approximately 646,551 gasoline-powered passenger cars from the road each year [5].

## 1.2 Proposed $CO_2$ Sequestration System Discussion

High Plains proposes to construct and operate six injection wells as discussed in this application, designed to sequester up to a total of 5.1 MMT/yr. The Spirea I-1 injection well is designed to sequester up to 1.5 MMT/yr. A single monitoring well, Spirea M-1, will be drilled and completed to monitor the confinement of the $CO_2$ plume from Spirea I-1 injection within the EWS Hub. The Juniper M-1 was drilled in the first quarter of 2023 as a stratigraphic test well and is proposed as an above-zone monitoring well for the Juniper I-1 well. Table 1.1 provides the location details for the EWS Hub wells. Figure 1.1 provides a conceptual overview of the project including the injection wells, their projected plumes, and the proposed monitoring well.

[5] "Greenhouse Gas Equivalencies Calculator." Environmental Protection Agency, March 2021, www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

Table 1.1—Location details for the EWS Hub wells.

| **Proposed Facility Location** | | | | | | |
|---|---|---|---|---|---|---|
| **County** | **Latitude*** | **Longitude*** | **Section** | **Township** | **Range** | **Qrt-Qrt** |
| Laramie | 41.052367 | -104.424469 | 34 | 13N | 63W | SW/NW |
| Facility Address: TBD | | | | | | |
| **Well Name** | **Latitude*** | **Longitude*** | **Section** | **Township** | **Range** | **Qrt-Qrt** |
| **Proposed Injection Well Locations** | | | | | | |
| Juniper I-1 | 41.055976 | -104.272853 | 36 | 13N | 62W | NW/NW |
| Azalea I-1 | 41.101266 | -104.334272 | 8 | 13N | 62W | SE/SE |
| Cypress I-1 | 41.086491 | -104.214625 | 16 | 13N | 61W | SW/SW |
| Barberry I-1 | 41.135708 | -104.251332 | 31 | 14N | 61W | NW/SW |
| Old Barberry I-1 | 41.200677 | -104.144977 | 12 | 14N | 61W | NW/NE |
| Spirea I-1 | 41.052367 | -104.424469 | 34 | 13N | 63W | SW/NW |
| **Deep Monitoring Well Locations** | | | | | | |
| Juniper M-1 | 41.05596 | -104.271944 | 36 | 13N | 62W | NW/NW |
| Azalea M-1 | 41.101258 | -104.333361 | 8 | 13N | 62W | SE/SE |
| Cypress M-1 | 41.086486 | -104.213715 | 16 | 13N | 61W | SW/SW |
| Barberry M-1 | 41.135701 | -104.25042 | 31 | 14N | 61W | NW/SW |
| Old Barberry M-1 | 41.200623 | -104.144074 | 12 | 14N | 61W | NW/NE |
| Spirea M-1 | 41.052315 | -104.423568 | 34 | 13N | 63W | SW/NW |

*NAD 83

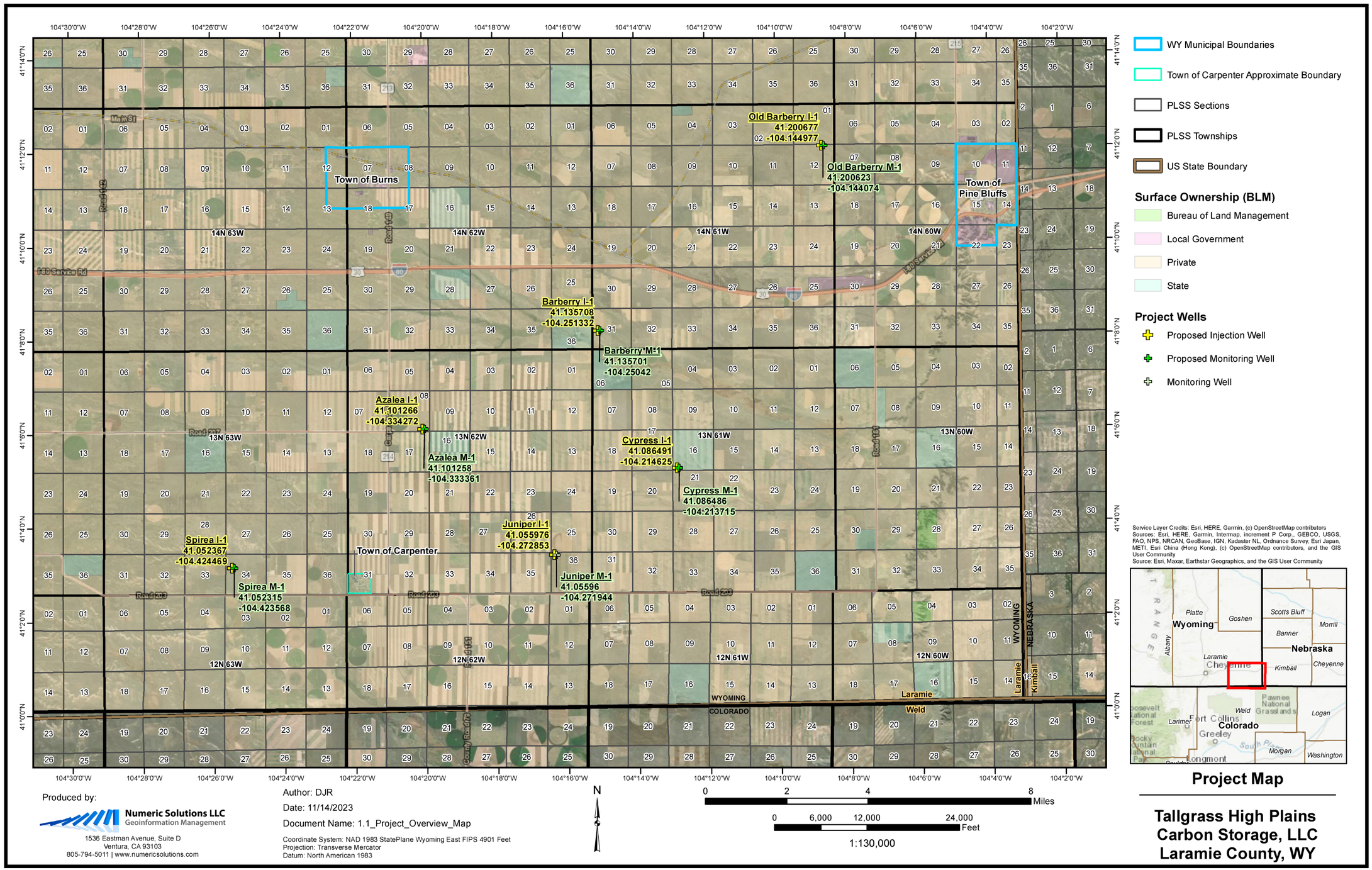


Figure 1.1—Overview map of the Eastern Wyoming Sequestration (EWS) Hub.

## 1.3 Injection Strategy

The injection strategy for Spirea I-1 entails injecting into a single interval spanning approximately 50–100 net feet of clean, porous, and permeable sands in the Lyons Formation, which is frequently targeted for disposal across the region.

The calculated average or typical anticipated surface operating pressure for the initial storage well is estimated to land between 1,100 and 1,650 pounds per square inch gauge (psig), depending on the injection rate, using 4 ½ in. tubing. The pressure generated at the compressor for injection into the well will be higher at the compressor outlet, to overcome the frictional losses in the flowlines. A full discussion of operating and reservoir pressure effects is in *Section 2.4.1*.

## 1.4 Stratigraphic Test Well Discussion

A stratigraphic test well, named Juniper M-1, was drilled, logged, and cored in the first quarter of 2023. This test well is located approximately 8 miles east of the proposed Spirea I-1 location. The current simulation model has such a high level of confidence with the new site specific data collected from the stratigraphic well. Based on the proximity of the test well to the injection wells, the reservoir parameters derived from Juniper M-1 are expected to closely represent those of Spirea I-1. The model inputs will be confirmed through sample acquisition during the drilling of Spirea I-1 and the plume model either verified or updated at that time.

## 1.5 Injectate Information

Spirea I-1 is designed to receive approximately 1.5 MMT/yr of concentrated $CO_2$. The chemistry of the injectate stream will consist of approximately 95% $CO_2$ and less than 150 parts per million (ppm) of $H_2O$. A full description of the injectate composition is discussed in *Section 5—Injection Well Operations*.

Consistent with Chapter 24 of WYDEQ's Water Quality Rules (020-0011-24 Wyoming Code R. **§10(b)(xviii)**), High Plains will show the compatibility of the carbon dioxide stream with the fluids in the injection zone and minerals in both the injection and confining zones, based on the results of the formation testing program. The $CO_2$ streams that High Plains proposes to inject through this Class VI permit are exempt from the Environmental Protection Agency's (EPA) definition of hazardous waste (Title 40, U.S. Code of Federal Regulations (Title 40, **§261.4[h]**). Similarly, the injected carbon dioxide is not a hazardous or toxic waste or other material under Chapter 8 of WYDEQ's Water Quality Rules (020-0011-8 Wyoming Code R. **§6**). As such, the $CO_2$ streams that High Plains proposes to inject under this permit are not subject to the restrictions in said chapter.

## 1.6 Site Suitability

In the process of developing the EWS Hub and in compliance with WYDEQ Water Quality Rules Chapter 24 (020-0011-24 Wyoming Code R. **§10** and **§12**) [6], an evaluation of the proposed site was generated and considered the following:

- The location of the proposed injection well, monitoring well, and area of review (Project Site)
- Consideration of the Project Site as well as the broader area around it (Project Area) relative to federal sites/buildings/facilities, etc.
- Endangered species research
- Existing infrastructure, surface, and subsurface mines or quarries
- Faults or fractures in the Project Area based on seismic analysis or geophysical well-log characterization
- State or federal subsurface cleanup sites within the Project Area
- Environmental justice issues
- Artificial penetrations
- Drinking water in the area
- Other site-related issues

## 1.7 Injection Well Summary and Operational Overview

The proposed Spirea I-1 will be located in Section 34, Township 13N, Range 63W in Laramie County. The well will be vertically drilled to approximately 9,711 ft below ground surface (bgs), with a proposed gross injection interval estimated to be between 9,447 and 9,511 ft bgs.

The geology within the gross injection interval consists of a Permian-aged sand package, the Lyons Formation, bounded by the upper confining layers—the Chugwater and Goose Egg formations—and the lower confining layer, the Satanka Formation. The Lyons Formation is the target sequestration interval for the EWS Hub due to the identification of a thick, regional sand body with thick, continuous upper and lower confining layers. The net thickness of the Lyons sand is estimated to be approximately 50-60 ft at this location and contains sufficient reservoir properties to store $CO_2$. The Lyons is saline saturated (>10,000 ppm) and anticipated to have porosity of approximately 18% and permeability of approximately 330 millidarcy (mD). The overlying Chugwater and Goose Egg formations, which contain very low porosities (<5%) and permeabilities (0.01 mD), provide up to 500 ft of a regionally expansive quality seal that is ideal for carbon sequestration at this location.

Spirea I-1 will be designed and operated in a manner that meets the requirements of WYDEQ Chapter 24. Once injection activity is complete, the wells will be plugged according to WYDEQ Chapter 24 **§23**. Total site closure will occur after the post-injection monitoring period is complete.

[6] Hereafter, these references are abbreviated to chapter and section numbers only (e.g., "WYDEQ Chapter 24 **§10**") for brevity, with the full citations as shown here implied.

The proposed monitoring system is designed to meet the requirements of WYDEQ Chapter 24 **§20**, with advanced technologies that allow for the tracking of the injectate plume migration while minimizing the artificial creation of potential pathways for sequestered fluids to escape confinement. Seismic surveys will be utilized during the injection and post-injection periods to assess $CO_2$ migration across the Project Area. Spirea M-1 will be used to detect any migration above the confining interval.

## 1.8 Summary

This application will demonstrate that the Spirea I-1 location is ideally situated for the permanent storage of captured $CO_2$ for several reasons, including but not limited to:

- The Lyons Formation is an excellent injection interval of continuous, thick, high-porosity (±18%) and high-permeability (±330 mD) sandstone. Spirea I-1 is expected to sequester 1.5 MMT/yr for a total of 10.6 MMT.
- The Lyons Formation is bounded by contiguous upper (Chugwater/Goose Egg) and lower (Satanka) confining layers comprised of shales and siltstones.
- The Lyons Formation and confining seal units are not structurally complex. The formations have a gentle local and regional structural dip with no identified faults or geologic hazards within the modeled plume extents.
- Three artificial penetrations currently exist within the modeled plume extents: Juniper M-1, Fritz 1, and UPRR Palm 1-21. Juniper M-1 is the characterization well for the EWS Hub and is designed to prevent the migration of fluids to the Underground Sources of Drinking Water (USDWs) and the well will be plugged back above the injection (Lyons) and confining zones (Goose Egg/Chugwater) to prevent the migration of fluids. UPRR Palm 1-21 was drilled and abandoned and contains no production casing but has adequate cement plugs. Fritz 1 will have remedial work prior to $CO_2$ injection.
- High Plains will control the pore space occupied by the modeled plume.
- Saturations indicate that the zone is saline, with no economically recoverable hydrocarbon resources within the gross injection interval within the plume.
- The proposed injection and monitor wells have been designed to preserve seal integrity beyond the life of the asset. Wellbores will be constructed with metallurgies and acid-resistant cement to protect groundwater resources.

# 2 SITE CHARACTERIZATION

## 2.1 Overview of Project Area Geology

This proposed EWS Hub $CO_2$ injection site will be located in Laramie County, in southeastern Wyoming, approximately 5–10 miles northeast of the community of Carpenter (Figure 2.1). The site is situated within the Denver Basin, commonly referred to as the Denver-Julesburg Basin or "DJ Basin" (Figure 2.2).

The DJ Basin consists of Cenozoic through Paleozoic sediments deposited unconformably over Precambrian crystalline basement rock. Deposition occurred in a predominately marine shelf environment that was subject to subsidence for most of the Paleozoic and Mesozoic eras. As a result, total sediment accumulation can reach thicknesses in excess of 13,000 ft along the synclinal axis. Sediment supply during Pennsylvanian time consisted primarily of shale and carbonate in the basin interior with sand contribution along the Ancestral Rockies.

Permian through Triassic time was characterized by a broad, low-relief intermittent sea that exhibited depositional environments from fluvial, normal marine, to hypersaline. Lithology within the Permian-Triassic strata is dominated by red beds, evaporites, and anhydritic siltstones (Bethke and Lee 1994). Triassic sediments were subsequently overlain by shale and sand deposition that dominated the Jurassic and Cretaceous periods. The Western Interior Seaway was relatively deep and present across a significant portion of western North America during the Cretaceous, including the DJ Basin. The Cretaceous was also subject to east-verging thrusts associated with Laramide tectonism.

The combination of the structural setting and depositional environment resulted in accumulation of up to 10,000 ft of Cretaceous shale, sandy shale, and carbonate over Jurassic and Triassic sediments throughout the basin (Sonnenberg and Weimer 1981; Bethke and Lee 1994; Taucher et al. 2013). These shales and tight carbonate formations have been identified by the Wyoming State Geological Survey (WSGS) as confining intervals between the injection formation and the lowermost confirmed USDWs—assisting in isolating and protecting the USDWs from the proposed injection interval. Figure 2.2 depicts the stratigraphic column as expected to be encountered at Spirea I-1.

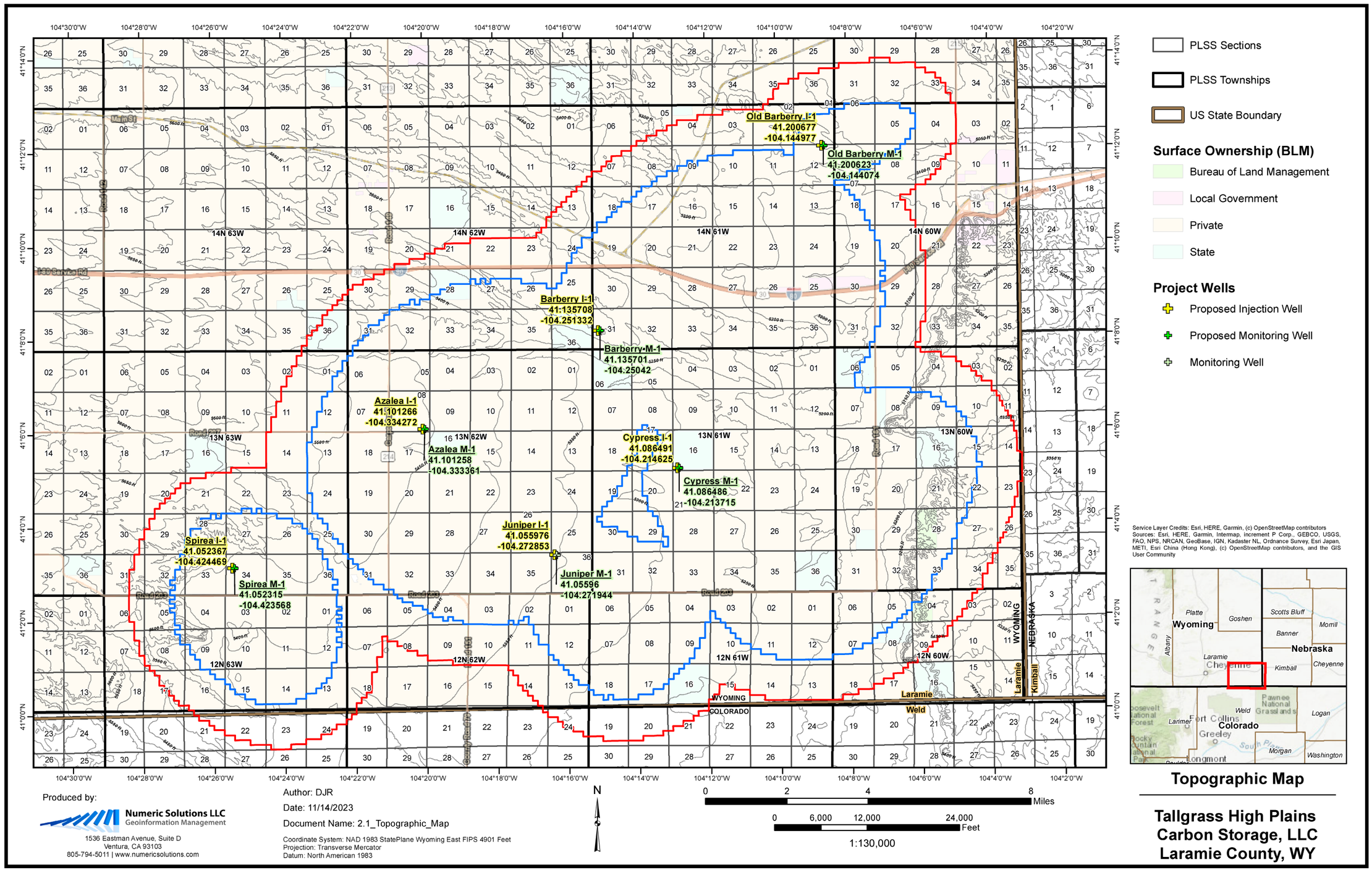


Figure 2.1—Topographic map of the project site.

<table>
<tr><th>ERATHEM</th><th colspan="2">SYSTEM AND SERIES</th><th colspan="5">Lithostratigraphic units of Love et al. (1993) in the DJ Basin (MODIFIED)</th><th colspan="3">Hydrogeologic unit for DJ Basin</th></tr>
<tr><td rowspan="11">CENOZOIC</td><td>QUATERNARY</td><td>Holocene and Pleistocene</td><td colspan="5">Alluvium and terrace deposits</td><td colspan="2">Quaternary unconsolidated-deposit aquifers</td><td rowspan="4">High plains aquifer system</td></tr>
<tr><td rowspan="4">TERTIARY</td><td>Pliocene</td><td colspan="5">section absent due to erosion or nondeposition</td><td colspan="2"></td></tr>
<tr><td>Miocene</td><td colspan="5">Ogallala Formation</td><td colspan="2">Ogallala aquifer</td></tr>
<tr><td rowspan="2">Oligocene</td><td colspan="5">Arikaree Formation</td><td>Arikaree aquifer</td><td></td></tr>
<tr><td rowspan="2">White River Formation</td><td>Conglomerate</td><td rowspan="2">White River Group</td><td></td><td>White River Group</td><td></td></tr>
<tr><td>Lower part</td><td>Brule Formation</td><td>White River aquifer/confining unit</td><td>Brule</td></tr>
<tr><td colspan="3">Chadron Formation</td><td></td><td>Chadron</td></tr>
<tr><td>Eocene</td><td colspan="8">section absent due to erosion or nondeposition</td></tr>
<tr><td>Paleocene</td><td colspan="8"></td></tr>
<tr><td rowspan="17">MESOZOIC</td><td rowspan="10">CRETACEOUS</td><td rowspan="7">Upper Cretaceous</td><td colspan="5">Lance Formation</td><td colspan="2">Lance aquifer</td><td rowspan="2">Lance-Fox Hills aquifer</td></tr>
<tr><td colspan="5">Fox Hills Sandstone</td><td colspan="2">Fox Hills aquifer</td></tr>
<tr><td colspan="5">Pierre Shale</td><td colspan="3">Pierre confining unit</td></tr>
<tr><td colspan="5">Niobrara Formation</td><td colspan="3">Niobrara confining unit</td></tr>
<tr><td colspan="5">Carlile Shale</td><td colspan="3">Carlile confining unit</td></tr>
<tr><td colspan="5">Greenhorn Formation</td><td colspan="3">Greenhorn confining unit</td></tr>
<tr><td colspan="5">Belle Fourche Shale</td><td colspan="3">Belle Fourche confining unit</td></tr>
<tr><td rowspan="3">Lower Cretaceous</td><td colspan="5">Mowry Shale</td><td rowspan="3">Mowry-Thermopolis confining unit</td><td></td></tr>
<tr><td colspan="5">Muddy Sandstone</td><td>Muddy Sandstone aquifer</td></tr>
<tr><td colspan="5">Thermopolis Shale</td><td></td></tr>
<tr><td colspan="2">Inyan Kara Group</td><td colspan="3">Fall River Formation</td><td colspan="3">Inyan Kara aquifer</td></tr>
<tr><td colspan="2"></td><td colspan="3">Lakota Formation</td><td colspan="3"></td></tr>
<tr><td rowspan="2">JURASSIC</td><td>Upper Jurassic</td><td colspan="5">Morrison Formation</td><td colspan="3">Morrison aquifer and confining unit</td></tr>
<tr><td>Middle Jurassic</td><td colspan="5">Sundance Formation</td><td colspan="3">Sundance aquifer</td></tr>
<tr><td colspan="3">JURASSIC (?) AND TRIASSIC (?)</td><td colspan="5">section absent due to erosion or nondeposition</td><td colspan="3"></td></tr>
<tr><td rowspan="2">TRIASSIC</td><td>Upper Triassic</td><td colspan="5">Chugwater Formation of Darton (1908)</td><td colspan="3">Chugwater confining unit</td></tr>
<tr><td>Lower Triassic</td><td colspan="5">Lykins Formation</td><td colspan="3">Goose Egg Formation</td></tr>
<tr><td rowspan="4">PALEOZOIC</td><td colspan="2" rowspan="2">PERMIAN</td><td colspan="5">Lyons Sandstone</td><td colspan="3">Hydrogeologic role/unit not defined for study area</td></tr>
<tr><td colspan="5">Satanka Shale</td><td colspan="3">Satanka confining unit</td></tr>
<tr><td rowspan="2">PENNSYLVANIAN</td><td>Upper Penn</td><td colspan="2" rowspan="2">Casper Formation</td><td colspan="3" rowspan="2">Hartville Formation</td><td rowspan="2">Casper aquifer</td><td rowspan="2">Hartville aquifer</td><td rowspan="2">Paleozoic aquifer system</td></tr>
<tr><td>Middle Penn</td></tr>
</table>

Figure 2.2—Stratigraphic column of the DJ Basin. The shading indicates confirmed USDWs in blue, the proposed injection interval in red, primary confining layers in dark gray, and additional confining layers in light gray (adapted and modified from Taucher et al. 2013).

The proposed injection interval is the Permian Lyons Formation, which was identified as a strong candidate for carbon sequestration by the Bureau of Economic Geology in the 2003 Technical Summary: *Optimal Geological Environments for Carbon Dioxide Disposal in Brine Formations (Saline Aquifers) in the United States* (Hovorka et al. 2003). Containment is provided by the underlying Satanka and overlying Chugwater and Goose Egg confining zones. The thick Cretaceous shale section previously mentioned overlies the lower Cretaceous and provides

significant additional confining strata between the proposed injection zone and exploited drinking water aquifers.

General lithologic descriptions of critical injection intervals are included and can be referenced to the stratigraphic column depicted in Figure 2.2. Lithologic descriptions of major aquifers, minor aquifers, marginal aquifers, and aquitards identified by the WSGS are covered in Section 2.2.1.1. Every stratigraphic interval from surface to Precambrian was deemed a potential aquifer or aquitard by the WSGS; thus, the entire stratigraphic column is described.

**Upper Confining Zone:** Triassic Chugwater Formation

The Chugwater Formation conformably overlies the Goose Egg Formation and unconformably underlies the Sundance Formation. It is comprised of reddish-orange shale and siltstone with thin gypsum partings near the base. The Chugwater was likely deposited in an aeolian, dry environment that had intermittent streams. Literature estimates a thickness of approximately 250 ft (Lowry and Crist 1967; Love and Christiansen 1985).

**Upper Confining Zone:** Late Permian-Early Triassic Goose Egg Formation

This geologic section consists of approximately 200 ft of red shale and silt interbedded with gypsum, anhydrite, limestone, and dolomite. It includes the Flowerpot Shale, Blaine anhydrite, Opeche Shale, Minnekahta Limestone, Glendo Shale, Forelle Limestone, Ervay Limestone, and Little Medicine Limestone members where present in the geologic section (Burk and Thomas 1956; Lowry and Christ 1967; Love and Christiansen 1985). The Goose Egg Formation was likely deposited as windblown dust on a flat, wet landscape. The limestone and dolostone beds were deposited in a shallow marine environment, which is further indicated by stromatolites, ostracods, foraminifera, sponge spicules, gastropods, and bivalves within the formation (Hagadorn 2019).

A significant disconformity is present at the base of the Jurassic, resulting in stratigraphic variability and complicated nomenclature among regions (Sonnenberg and Weimer 1981). Figure 2.3 clarifies nomenclature among the regions and provides a suggested nomenclature use for subsurface rocks of the DJ Basin. The geologic section is typically referred to as the “Goose Egg Group” in Wyoming and the “Lykins Formation” in Northern Colorado (Campbell 1963). Hereafter, this geologic section will be referred to as the “Goose Egg” Formation.

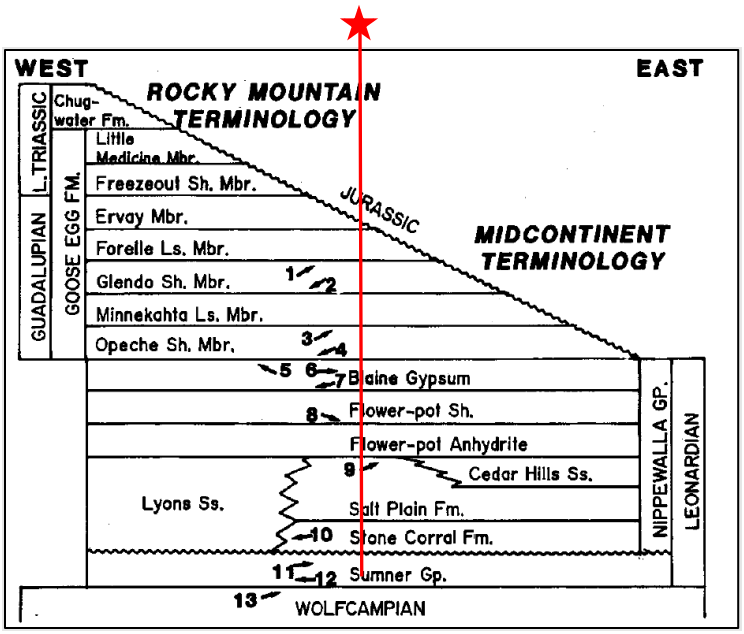

Figure 2.3—Suggested nomenclature for post-Wolfcampian, pre-Jurassic rocks of the subsurface DJ Basin (Oldham 1996). The red star is the approximate location of the EWS Hub.

Members anticipated to be encountered are described, along with common regional nomenclatures:

**Glendo Shale:** Slightly platy, red to ocher, sandy, gypsiferous shale and siltstone. Shale overlying Forelle Limestone contains thin gypsum partings with increasing evaporite content working up the section (Burk and Thomas 1956). Guadalupian in age (Campbell 1963).

**Forelle Limestone:** Hard, gray, dense, stromatolitic limestone containing gray to dark gray chert nodules (Burk and Thomas 1956). Guadalupian in age. Forelle nomenclature consistent between regions (Campbell 1963). Anticipated to be present within Glendo Shale.

**Minnekahta Limestone:** Hard gray limestone containing slabby bedding (Love and Christiansen 1985). Guadalupian in age. Minnekahta nomenclature consistent between regions (Campbell 1963).

**Opeche Shale:** Soft, red, sandy shale. Member of the Goose Egg Formation (Love and Christiansen 1985). Likely Leonardian in age (Campbell 1963).

**Flowerpot Shale:** Primarily shale that is highly gypsiferous and contains clays of various colors. Literature estimates a thickness of approximately 150 ft (Love and Christiansen 1985).

The Chugwater Formation and underlying Goose Egg Formation act as the primary overlying confining zone for the Lyons Formation. Facies described as gypsum are expected to be anhydrite or halite in the subsurface due to compaction and dewatering that tends to occur along with burial (Murray 1964).

**Primary Injection Zone:** Permian Lyons Formation

The Lyons Formation is described as a well-sorted, fine-grained, aeolian quartzose sandstone from outcrops near Lyons, Colorado (Sonnenberg and Weimer 1981). However, lithofacies vary

due to complex depositional environments and diagenetic cementation, ranging from sandstone to evaporites, carbonate, red shale, and conglomerate (Hovorka et al. 2003; Bethke and Lee 1994). Red beds comprise most of the sandstone and contain quartz overgrowths, calcite cements, and iron oxide coating. Diagenetic alteration removed iron oxide and calcite cements, which resulted in the gray diagenetic facies associated with petroleum accumulation and productive fields of the Lyons Formation (Bethke and Lee 1994). Based on offset correlations, the Lyons Formation has an average thickness of 50–100 ft near the proposed Spirea I-1 site.

**Lower Confining Zone:** Permian Satanka Formation

The Satanka Formation contains interbedded red and gray sandstones, gray siltstone, red mudstone, and red anhydritic siltstones. The sandstones contain feldspar and are commonly fine-grained to very fine-grained. This formation has been interpreted as a mixture of fluvial, flood plain, mud flat, and desert lake deposits (Sonnenberg and Weimer 1981). The anhydrite-rich upper Satanka provides an impermeable cap, inhibiting vertical fluid migration (Clayton and Swetland 1980). Based on offset correlations, the Satanka has an average thickness of approximately 200 ft near the proposed Spirea I-1 site.

## 2.2 Regional Geology and Geologic Structure

The DJ Basin is an elongated, asymmetrical structure that formed during the Laramide orogeny. The Laramie and front ranges of Wyoming and Colorado bound the structure to the west with the basin axis running just east of the mountain front. The deepest portion of the basin is found along the axis, with steep dips out of the western flank that can exceed ten degrees. The basin extends 150 miles east into Kansas and Nebraska with strata dipping gently west toward the basin axis. The DJ Basin is bounded to the north by the Hartville Uplift and the south by the Apishapa Uplift (Sonnenberg and Weimer 1981; Hovorka et al. 2003; Bartos et al. 2021; Bethke and Lee 1994).

The generalized basement structure map of the DJ Basin depicted in Figure 2.4 includes a red star identifying the approximate location of the EWS Hub. The present structural setting of the northern DJ Basin is illustrated in the schematic cross section in Figure 2.5. The basin has a regional dip to the west and appears to exhibit relatively gentle structural trends around the EWS Hub location.

A locator map (Figure 2.6) and regional cross sections (Figure 2.7 and Figure 2.8—Regional north-to-south cross section B-B’ extending from surface through the base of the lower confining zone. Representative well logs outside of the AoR that penetrate the injection zone are included.) were constructed by High Plains with well logs to convey the regional geologic interpretation of the EWS Hub area. The cross sections represent geologic sections from surface to Precambrian basement, providing regional context to the project. Section 2.4.1.4 contains local cross sections through the area of review and proposed injection well (Figure 2.27 through Figure 2.28) to provide additional clarity of the structure and stratigraphy within the AoR. Both cross sections demonstrate a consistent structural interpretation with laterally extensive confining and injection intervals.

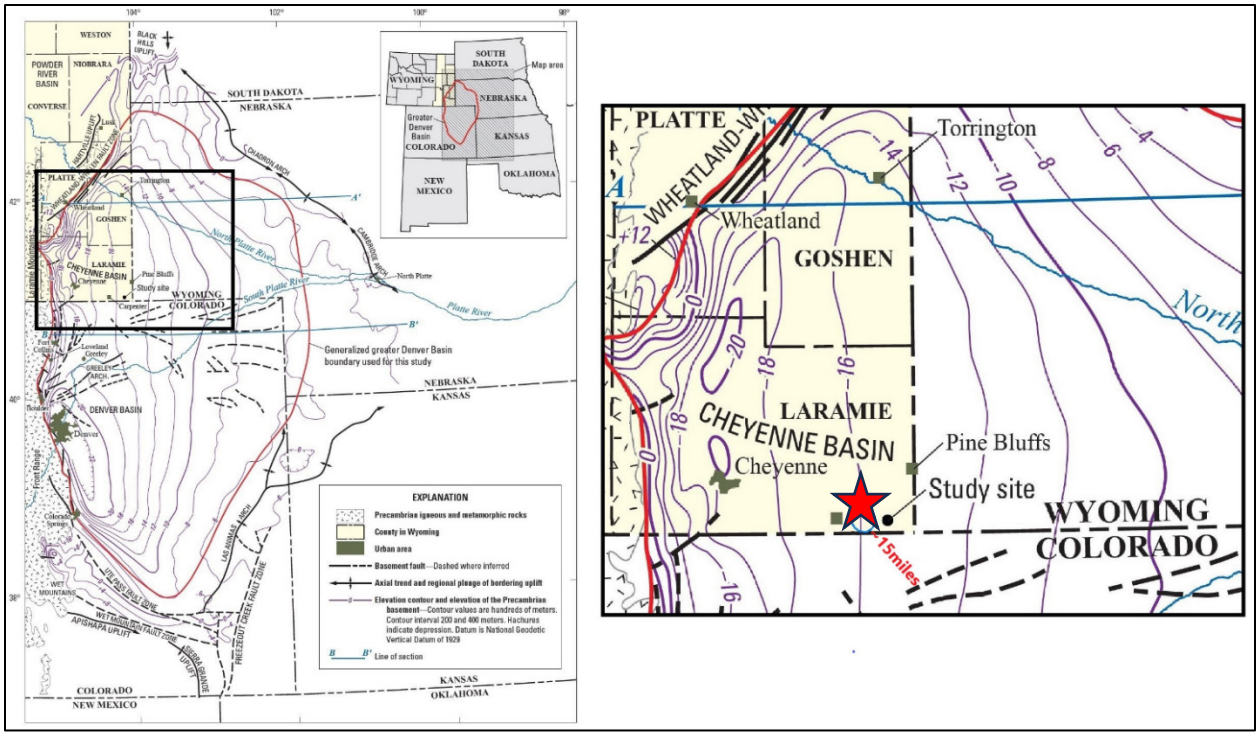


Figure 2.4—Generalized Precambrian basement structure of the greater DJ Basin in Wyoming, Nebraska, Colorado, and Kansas (Bartos et al. 2021). The red star is the approximate location of the EWS Hub. Note there is no interpreted faulting within the vicinity of the Hub.

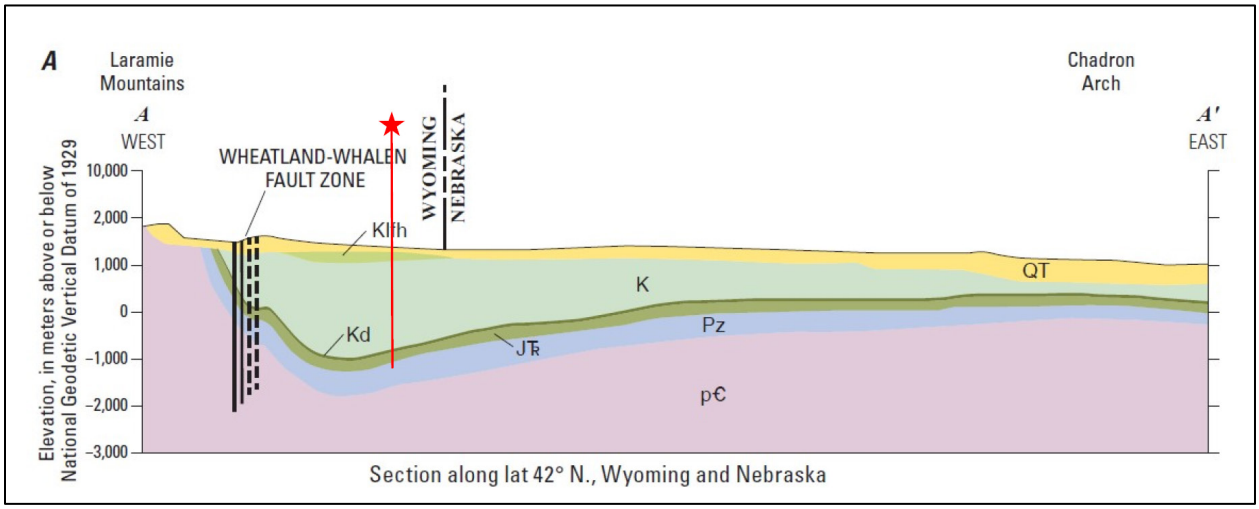


Figure 2.5—Schematic cross section along latitude 42° north, including Wyoming and Nebraska (Bartos et al. 2021). The red star is the approximate location of the EWS Hub. Note there is no interpreted faulting within the EWS Hub area.

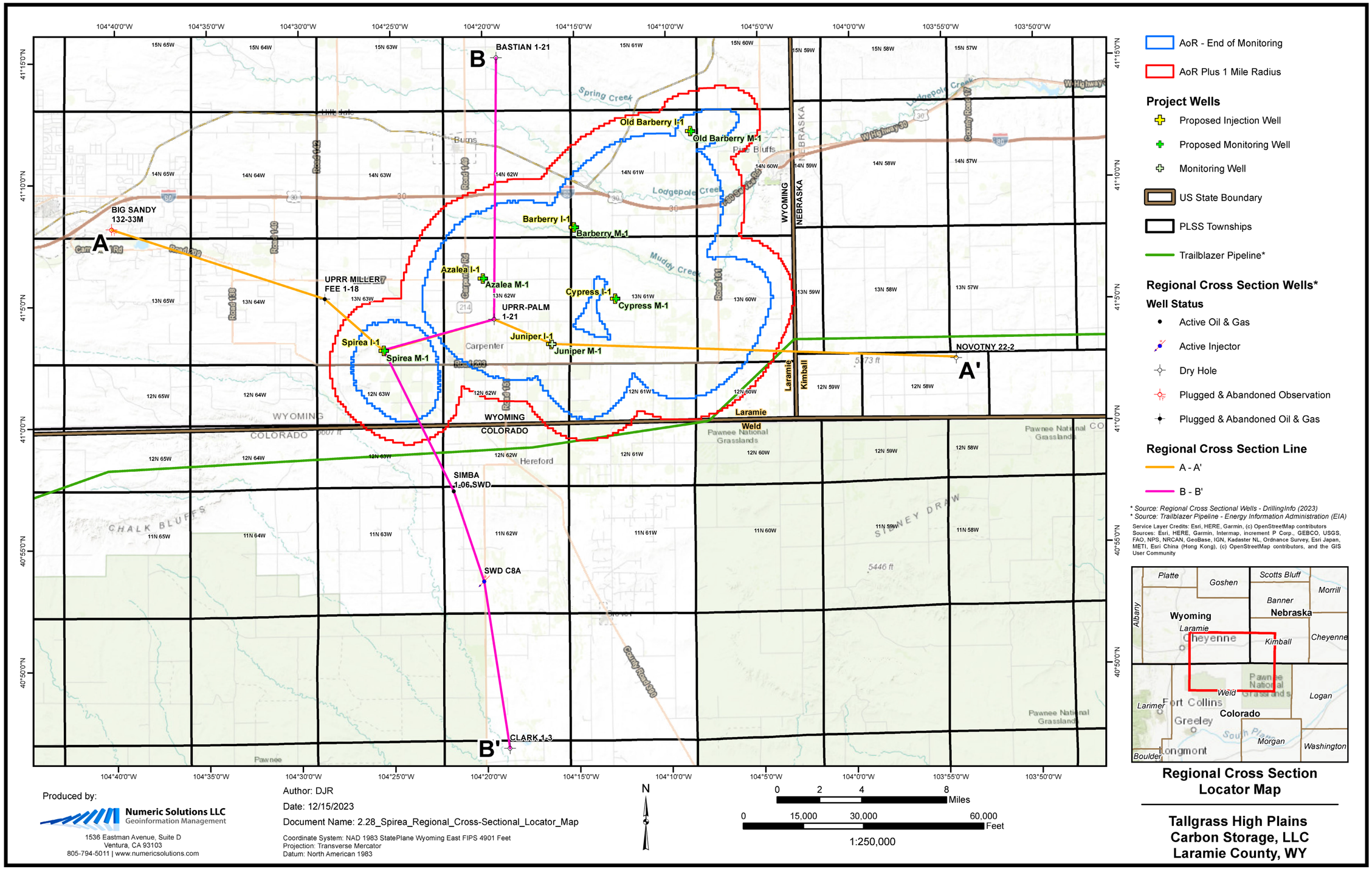


Figure 2.6—Regional cross-sectional locator map. The red star is the approximate location of the Spirea I-1 injection well. The A-A’ cross-sectional line is depicted in Figure 2.7. The B-B’ cross-sectional line is depicted in Figure 2.8—Regional north-to-south cross section B-B’ extending from surface through the base of the lower confining zone. Representative well logs outside of the AoR that penetrate the injection zone are included..

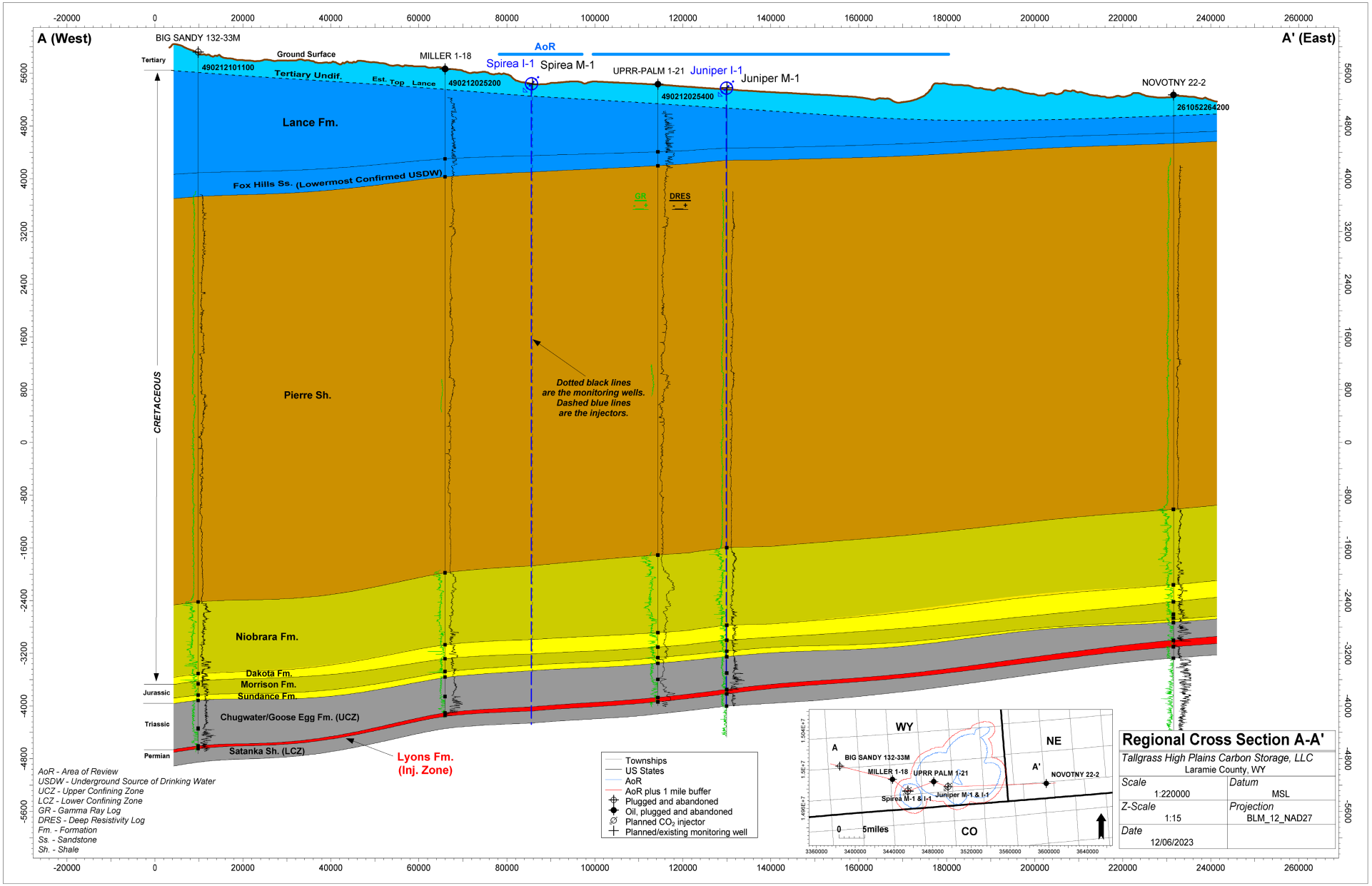


Figure 2.7—Regional west-to-east cross section A-A’ from surface through the base of the lower confining zone. Representative well logs outside of the AoR that penetrate the injection zone are included.

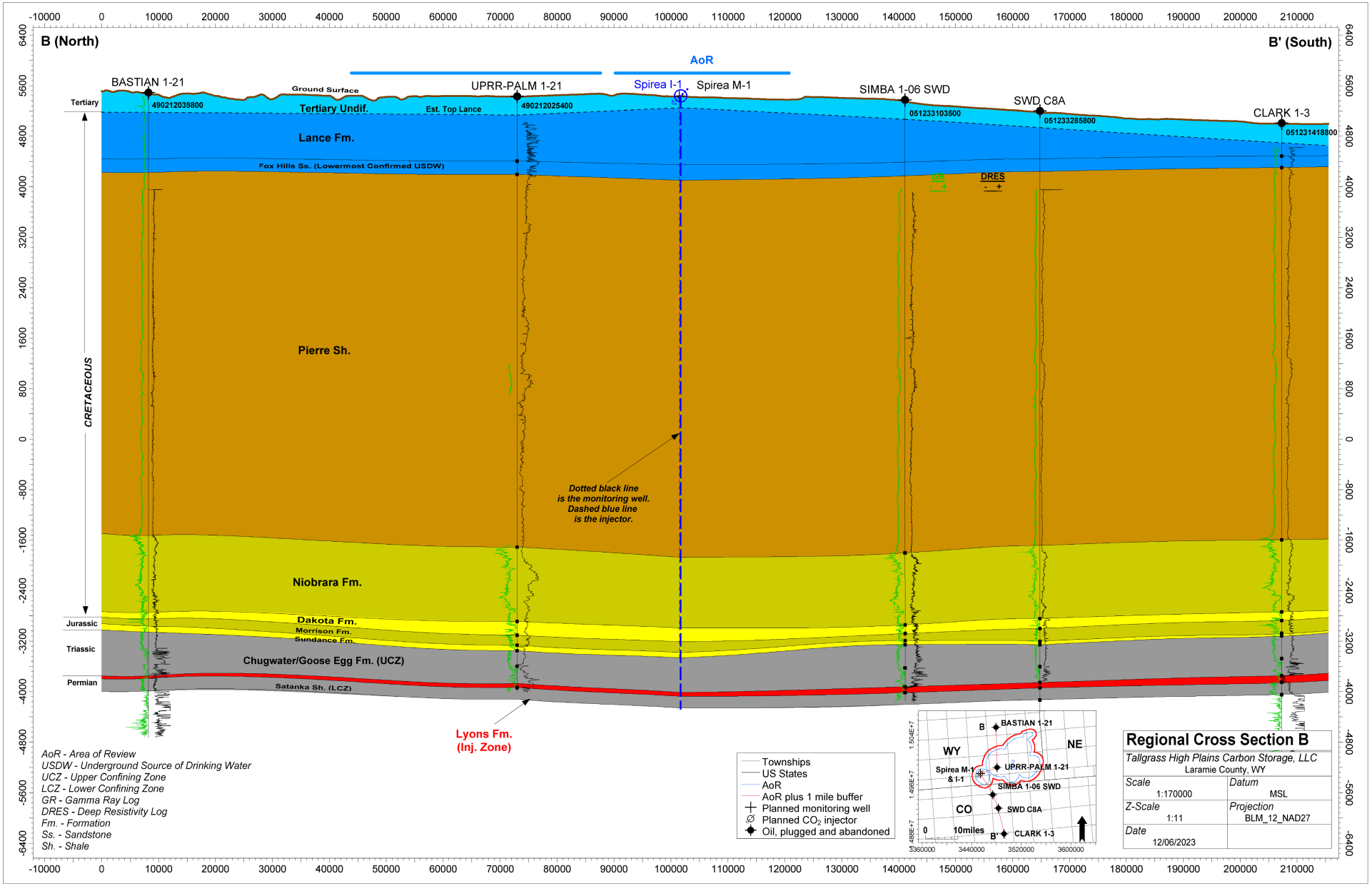


Figure 2.8—Regional north-to-south cross section B-B’ extending from surface through the base of the lower confining zone. Representative well logs outside of the AoR that penetrate the injection zone are included.

### *2.2.1 Regional Hydrostratigraphy*

In 2013, the Wyoming Water Development Commission (WWDC) released a detailed hydrostratigraphic review of Wyoming in their Water Plan Update Groundwater Study (Taucher et al. 2013). The WWDC sponsored the study, but the WSGS conducted it in association with the U.S. Geological Survey (USGS) and the Water Resources Data System (WRDS). The report identified seven major river basins in Wyoming that were further studied to determine the presence and extent of aquifers, areas of recharge, water quality and quantity, and development potential.

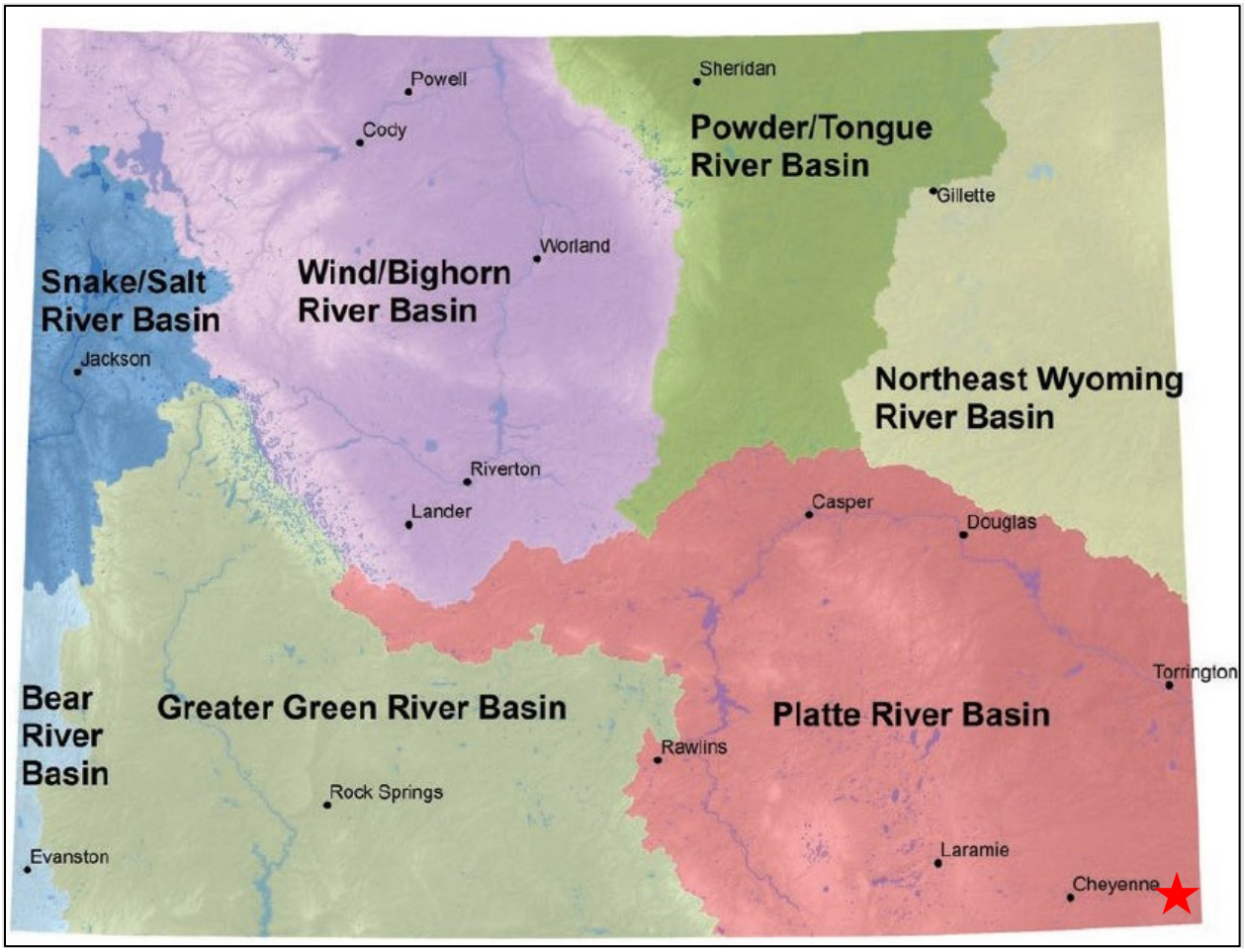


Figure 2.9—The major drainage basins of Wyoming (Taucher et al. 2013). The red star is the approximate location of the EWS Hub.

The EWS Hub is located within the Platte River Basin, as depicted in Figure 2.9. The Platte River Basin covers approximately 26,289 square miles and spans from central Wyoming into northern Colorado and western Nebraska (Taucher et al. 2013). Wyoming considers the surficial basin to be one of the more significant drainage basins because it covers one-quarter of the state and contains more than 40% of its population. The topography of the Platte River Basin varies greatly, ranging from 4,025 ft above sea level at the Wyoming-Nebraska state line to 12,013 ft at Medicine Bow Peak. The climate is semi-arid in the basin and transitions to humid-alpine in the

bordering mountain ranges where most of the atmospheric moisture is captured (Taucher et al. 2013).

The Platte River Basin is further divided into eight Wyoming subregions (Figure 2.10), which places the EWS Hub in the Denver Basin and Hartville Uplift subregion.

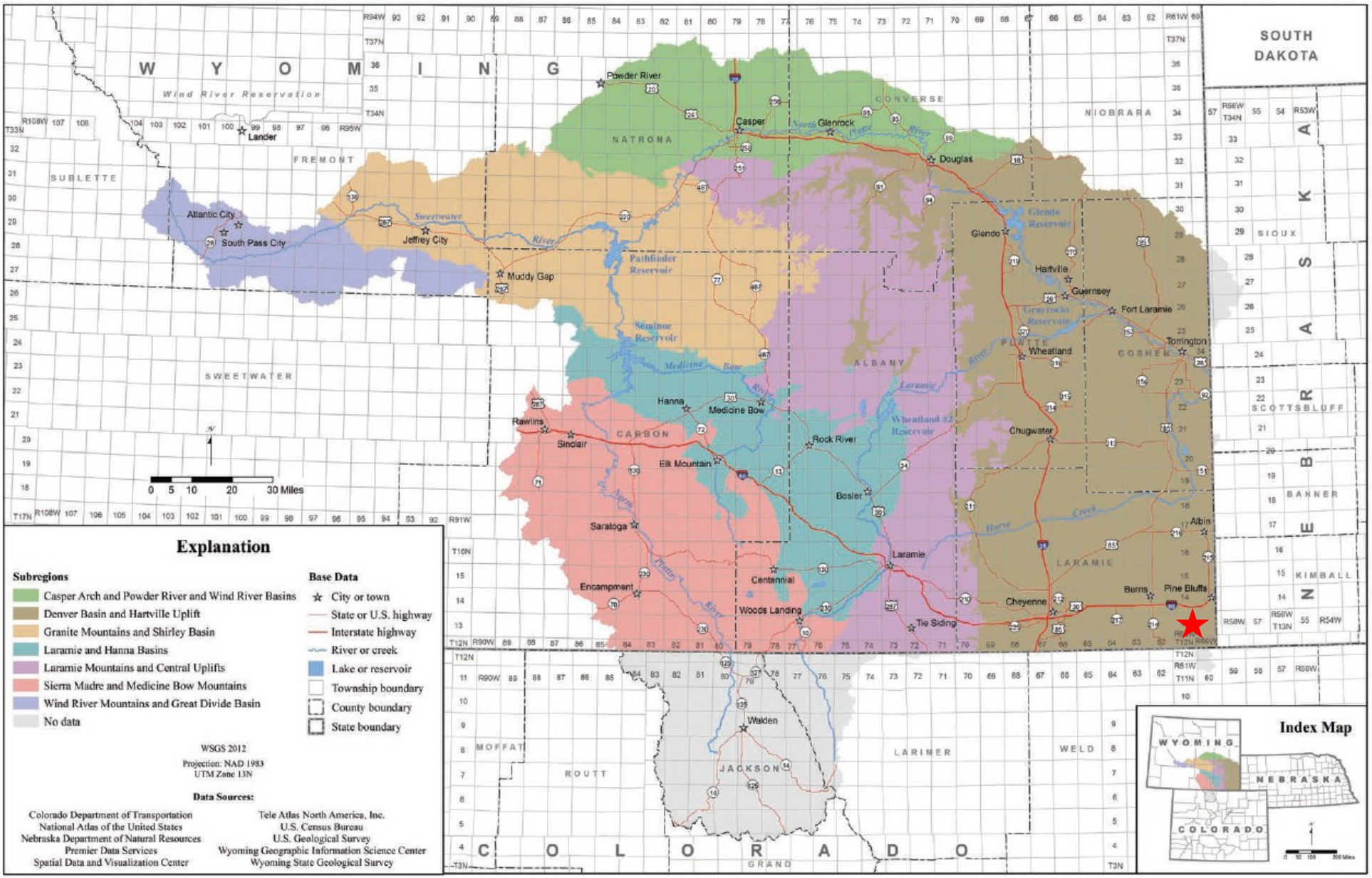


Figure 2.10—Map of the Wyoming Platte River Basin including the subregion, township, and range index map (Taucher et al. 2013). The red star is the approximate location of the EWS Hub.

The DJ Basin contains 14 potential aquifers identified in the 2013 WWDC Platte River Basin Water Plan Update (Plate M; Taucher et al. 2013) as shown in Table 2.1. Major aquifers, minor aquifers, marginal aquifers, and aquitards identified in the report are catalogued, with each list working down the stratigraphic column from youngest to oldest formations. The relationship of lithostratigraphic units to potential hydrogeologic units identified can be referenced in Figure 2.11.

Table 2.1—Southeast Wyoming potential aquifers.

| | |
|---|---|
| *Reported Major aquifers:*<br>○ Quaternary aquifers<br>○ Ogallala aquifer<br>○ Arikaree aquifer<br>○ Lance aquifer<br>○ Fox Hills aquifer<br>○ Casper aquifer<br>○ Hartville aquifer<br>○ Guernsey aquifer<br>○ Fremont Canyon aquifer<br><br>*Reported Minor aquifers:*<br>○ Inyan Kara aquifer<br>○ Morrison aquifer<br>○ Sundance aquifer | *Reported Marginal aquifers:*<br>○ White River aquifer<br>○ Casper aquifer<br>○ Hartville aquifer<br>○ Guernsey aquifer<br>○ Fremont Canyon aquifer<br><br>*Reported Major aquitards:*<br>○ Pierre confining unit<br>○ Niobrara confining unit<br>○ Carlile confining unit<br>○ Greenhorn confining unit<br>○ Belle Fourche confining unit<br>○ Mowry-Thermopolis confining unit<br>○ Morrison confining unit<br>○ Chugwater confining unit<br>○ Satanka confining unit<br>○ Precambrian basal confining unit |

| ERATHEM | SYSTEM AND SERIES | | Lithostratigraphic units of Love et al. (1993) in the DJ Basin (MODIFIED) | | | | Hydrogeologic unit for DJ Basin | | | Hydrogeologic role/unit of Statewide Framework water Plan (WWC Engineering et al., 2007) |
|---|---|---|---|---|---|---|---|---|---|---|
| CENOZOIC | QUATERNARY | Holocene and Pleistocene | Alluvium and terrace deposits | | | | Quaternary unconsolidated-deposit aquifers | | High plains aquifer system | Major Aquifer-alluvial |
| | TERTIARY | Pliocene | *section absent due to erosion or nondeposition* | | | | | | | |
| | | Miocene | Ogallala Formation | | | | Ogallala aquifer | | | Major aquifer-sandstone |
| | | | Arikaree Formation | | | | Arikaree aquifer | | | Major aquifer-sandstone |
| | | Oligocene | White River Formation | Conglomerate | White River G | | White River Group | | | Marginal aquifer |
| | | | | Lower part | | Brule Formation | White River aquifer/confining unit | Brule | | |
| | | | | | | Chadron Formation | | Chadron | | |
| | | Eocene | *section absent due to erosion or nondeposition* | | | | | | | |
| | | Paleocene | | | | | | | | |
| MESOZOIC | CRETACEOUS | Upper Cretaceous | Lance Formation | | | | Lance aquifer | | Lance-Fox Hills aquifer | Major aquifer-sandstone |
| | | | Fox Hills Sandstone | | | | Fox Hills aquifer | | | Major aquifer-sandstone |
| | | | Pierre Shale | | | | Pierre confining unit | | | Major aquitard |
| | | | Niobrara Formation | | | | Niobrara confining unit | | | Major aquitard |
| | | | Carlile Shale | | | | Carlile confining unit | | | Major aquitard |
| | | | Greenhorn Formation | | | | Greenhorn confining unit | | | Major aquitard |
| | | | Belle Fourche Shale | | | | Belle Fourche confining unit | | | Major aquitard |
| | | | Mowry Shale | | | | Mowry-Thermopolis confining unit | | | Major aquitard |
| | | Lower Cretaceous | Muddy Sandstone | | | | | Muddy Sandstone aquifer | | Not discussed |
| | | | Thermopolis Shale | | | | | | | Major aquitard |
| | | | Inyan Kara Group | Fall River Formation | | | Inyan Kara aquifer | | | Minor aquifer |
| | | | | Lakota Formation | | | | | | |
| | JURASSIC | Upper Jurassic | Morrison Formation | | | | Morrison aquifer and confining unit | | | Minor aquifer |
| | | Middle Jurassic | Sundance Formation | | | | Sundance aquifer | | | Minor aquifer |
| | JURASSIC (?) AND TRIASSIC (?) | | *section absent due to erosion or nondeposition* | | | | | | | |
| | TRIASSIC | Upper Triassic | Chugwater Formation of Darton (1908) | | | | Chugwater confining unit | | | Major aquitard |
| | | Lower Triassic | Lykins Formation | | | | Goose Egg Formation | | | Major aquitard |
| PALEOZOIC | PERMIAN | | Lyons Sandstone | | | | Hydrogeologic role/unit not defined for study area | | | Major aquitard |
| | | | Satanka Shale | | | | Satanka confining unit | | | Major aquitard |
| | PENNSYLVANIAN | Upper Penn | Casper Formation | | Hartville Formation | | Casper aquifer | Hartville aquifer | Paleozoic aquifer system | Major aquifer-limestone |
| | | Middle Penn | | | | | | | | |

Figure 2.11—Relationship of lithostratigraphic units to potential hydrogeologic units within the DJ Basin (after Taucher et al. 2013). The blue shade represents potential major aquifers, minor aquifers, and marginal aquifers.

General lithologic descriptions of potential hydrogeologic units are provided along with supporting information to identify confirmed and potential underground sources of drinking water (USDWs). Descriptions and USDW designations are based on work performed by Taucher et al. (2013) and Brendecke and Hinckley (2014) unless otherwise noted. Additional discussions and data regarding potential USDW formations can be found in the summary following the descriptions, and in *Section 2.2.3* and *Section 3.2*.

***Major Alluvial Aquifer:*** *Quaternary unconsolidated-deposit aquifers*

The aquifers occur as flat-lying, unconsolidated, highly permeable sand and gravel layers that are interbedded with fine-grain sediments such as silt and clay. Flow through the unconsolidated

material occurs through primary intergranular porosity. Quaternary deposits are hydraulically connected to active streams, and most of the groundwater in storage is provided by direct infiltration from streams (Taucher et al. 2013). Deposits tend to occur as thin alluvial strips along streams and as more extensive terrace deposits. Terrace deposits are very productive despite their shallow depths and serve as a prevalent source of groundwater irrigation in Laramie County. Local terrace deposits vary in thickness and can reach thicknesses up to 200 ft with a saturated thickness of 80 ft in the Carpenter area (Brendecke and Hinckley 2014). This aquifer is anticipated to be present at the EWS Hub and is a USDW.

***Major Sandstone Aquifer:*** *Ogallala aquifer*

The Tertiary Ogallala Formation is part of a complex regional aquifer system that underlies large portions of the High Plains and has been developed extensively for groundwater irrigation. The Ogallala hosts the majority of domestic water wells for Laramie County and provides the majority of municipal water to the City of Cheyenne. Sediments found accommodation within paleochannels of the underlying Arikaree Formation, which resulted in the variable thickness of the Ogallala (Brendecke and Hinckley 2014). The aquifer occurs within permeable coarse-grained beds of the Ogallala consolidated sandstone and conglomerate (Taucher et al. 2013). Brendecke and Hinckley mention in their 2014 report that productive wells and unproductive wells can occur within close proximity. This is likely due to the irregular nature of permeable sand lenses and stringers that occur within less permeable silt and clay interbeds. Where present, the Ogallala is a USDW, however, maps published by Love and Christiansen (1985) and Brendecke and Hinckley (2014) indicate the Ogallala aquifer is anticipated to be thin and/or potentially unsaturated within the extents of the Spirea I-1 AoR.

***Major Sandstone Aquifer:*** *Arikaree aquifer*

The Tertiary Arikaree Formation is composed of partially consolidated to consolidated volcaniclastics and fine-grained sandstone to silty sandstone with interbeds of tabular limestone and carbonate mudrock. The Arikaree Formation was deposited in a fluvial and aeolian environment. Properties of the aquifer are highly variable due to lithologic heterogeneity and variable intergranular permeability (Taucher et al. 2013). These aquifers supply usable quantities of groundwater to Platte, Goshen, and Niobrara counties but are generally less productive than the Ogallala. The Arikaree Formation is present in the northeast portion of Laramie County and primarily developed where the Ogallala aquifer is unsaturated or absent (Brendecke and Hinckley 2014). Where present, the Arikaree is a USDW, however, maps published by Love and Christiansen (1985) and Brendecke and Hinckley (2014) indicate the Arikaree aquifer is anticipated to be thin and/or potentially unsaturated within the extents of the Spirea I-1 AoR.

***Marginal Aquifer:*** *White River aquifer and confining unit*

The Tertiary White River Formation is composed of partially consolidated to consolidated, argillaceous volcaniclastic mudrocks, including siltstone, mudstone, and claystone. Diagenesis devitrified White River volcaniclastic sediments over most of Laramie County, which resulted in the conversion of clay species to montmorillonite and kaolinite. These clay species are known for their profound confining properties and act as an aquitard within the formation (Taucher et al. 2013).

The White River Formation is commonly subdivided into the upper "fractured Brule" and lower "Chadron" members. The productive portion of the aquifer is found within the highly permeable Brule member while the Chadron is characterized by poor to moderate groundwater production. Production from the Brule is generally confined to southeastern Laramie County and along the eastern to northeastern flanks of the Laramie Mountains, within local coarse-grained deposits of arkosic conglomerates (Brendecke and Hinckley 2014). Groundwater yields from this unit vary depending on local physical characteristics. The thickness can reach up to 500 ft in Laramie County (Taucher et al. 2013). The White River aquifer is anticipated to be present at the EWS Hub and is a USDW.

***Major Aquifers:*** *High Plains aquifer*

It should be noted that the USGS groups the White River, Arikaree, and Ogallala formations as well as any Quaternary deposits into the "High Plains Regional Aquifer System" or "Tertiary Aquifer System" (Brendecke and Hinckley 2014). Reported data on containing formations may be specific or generalized to one of these nomenclatures. These aquifer systems and containing formations are USDWs.

***Major Sandstone Aquifers:*** *Lance aquifer*

The Lance Formation is upper Cretaceous in age. Aquifers of the Lance are found within fine- to medium-grained permeable sandstones that are interbedded with low permeability gray shale, black carbonaceous shale, and coal (Brendecke and Hinckley 2014). The gross thickness of the Lance Formation ranges from 200 ft in eastern Laramie County to 1,500 ft in the western portion of the county (Brendecke and Hinckley 2014). The aquifers are used for stock or domestic purposes due to poor water quality and moderate yields (Taucher et al. 2013). The Lance aquifer is anticipated to be present at the EWS Hub and is a USDW.

***Major Sandstone Aquifer:*** *Fox Hills aquifer*

The Fox Hills Formation is upper Cretaceous in age and composed of friable sandstone that is interbedded with dark sandy shale. Sandstone beds are typically gray to white or yellow to brown in color. The thickness ranges from 40–250 ft in Laramie County (Brendecke and Hinckley 2014). The Fox Hills aquifer was not developed until recently when a well was successfully completed for public supply, demonstrating that the aquifer has development potential (Taucher et al. 2013). However, the Lance and Fox Hills aquifers are not heavily exploited in the county, because shallower formations provide groundwater of higher quality and quantity, thus better economics. The Fox Hills aquifer is anticipated to be present at the EWS Hub and is the lowermost confirmed USDW in the area.

***Major Aquitards:*** *Pierre, Niobrara, Carlile, Greenhorn, Belle Fourche, and Mowry confining units*

These are thick, regionally extensive clay/shale-rich units that prevent groundwater from flowing between or into aquifers due to reduced hydraulic conductivity. The Pierre Shale is dark-gray shale with interbedded thin to moderately thick beds of sandstone. These sandstone beds, including the "Hygiene member" (Fenneman 1905) will locally yield small quantities of water in some areas and have been classified by Libra et al. (1981) as "discontinuous minor aquifers." It is unknown at this time if any of these intervals have fluid chemistries and yields within the project

area sufficient to meet the criteria for a USDW. They will be evaluated in the injection well at the time of drilling to determine if any meet USDW standards.

The Niobrara Formation is dark-gray calcareous shale with light-colored interbeds of limestone, chalk, and sandstone. The Carlile Shale, Greenhorn Limestone, and Belle Fourche Shale units are primarily shale with some limestone and sandstone. The Late Cretaceous Mowry Shale is siliceous shale that ranges from dark-gray to deep-brown to black in color and contains numerous bentonite interbeds (Taucher et al. 2013). The section does not contain aquifers as it is a confining interval and therefore individual formations are not USDWs.

***Minor Sandstone Aquifer:*** *Muddy aquifer*

The Early Cretaceous Muddy Sandstone aquifer lies between the Mowry-Thermopolis shales and is a fine to medium grained silty sandstone with buff to gray color. Permeability is low due to tight cementation and silty matrix; however, the formation has been found suitable for domestic, irrigation, and livestock use in some of the state, outside of the AoR (Taucher et al. 2013). Taboga and Stafford (2020) reviewed Muddy aquifer water tests in southeastern Wyoming. Based on the water analysis from samples collected from 30 wells, Taboga and Stafford (2020) reported an average TDS concentration of 13,856 mg/L. Therefore, within the AoR the Muddy likely does not meet the definition of a USDW. This finding will be confirmed in the future with further testing and samples.

***Major Aquitard:*** *Thermopolis confining unit*

The Early Cretaceous Thermopolis Shale is described as dark-gray to black shale with thin beds of sandstone, siltstone, and bentonite (Taucher et al. 2013). This zone is designated as a confining interval and not an aquifer, therefore is not a USDW.

***Minor Aquifer:*** *Inyan Kara aquifer*

Minor aquifers were differentiated because they are thinner than major aquifers, more diverse in nature, yield less water, and are contained within relatively limited lateral extents. The Early Cretaceous Inyan Kara minor aquifer consists of rusty to light-gray sandstone and cherty-pebble conglomerate interbedded with variegated bentonitic claystone. The Inyan Kara group has a complicated naming convention due to the presence of regional unconformities within the section and can also be referred to as the Lakota, Dakota, Fall River, or Cloverly formation depending on the extent of local sand bodies. High Plains' mapping of the total dissolved solids (TDS) of the Dakota sandstone estimates the EWS Hub location to have approximately 3,000 to 10,000 mg/L TDS with TDS increasing into Nebraska, indicating this zone may be a USDW. High Plains plans to collect its own fluid sample in the Dakota Formation in the Spirea I-1 to confirm whether the zone meets USDW criteria within the AoR. For the time being, High Plains is utilizing the Fox Hills as the lowermost USDW for modeling exercises as the zone is the lowermost aquifer currently utilized for groundwater extraction in the AoR and is the lowermost confirmed USDW.

***Minor Aquifer and Confining Unit:*** *Morrison aquifer/confining unit*

The Late Jurassic Morrison Formation consists of laterally discontinuous siltstones, marlstones, and claystones that occur in various dull colors. Intervals high in claystone and mudstone content

represent the confining layers of the Morrison Formation. Minor aquifers of the Morrison are limited to thin, gray silty-sandstone and a massive limestone bed where porosity tends to develop. The Morrison can yield small quantities of water for stock or domestic use when porous, permeable, reservoir is present and saturated with water of adequate quality (Love and Christiansen 1985; Taucher et al. 2013). Regional mapping performed by High Plains indicates the EWS Hub location will encounter confining shales within the Morrison Formation. Silty sandstones associated with minor aquifers of the Morrison Formation are not anticipated to be present within the at the proposed Spirea I-1 AoR, therefore within the AoR the Morrison is likely not an aquifer thus not a USDW.

***Minor Aquifer:*** *Sundance aquifer*

The Middle to Late Jurassic Sundance Formation is primarily light-tan sandstone with greenish-gray glauconitic sandy shale that is underlain by red to gray non-glauconitic sandy shale. Aquifers occur within intergranular porosity and permeability of well-sorted, well-rounded sandstone intervals (Lowry and Crist 1967; Love and Christiansen 1985; Taucher et al. 2013). High Plains was unable to locate any measured salinity data within or near the AoR (no data is available for the Sundance within the USGS National Produced Waters Geochemical Database[7] from Laramie County, WY nor the directly adjacent counties of Weld, CO and Kimball, NE). High Plains will sample and confirm the TDS concentration of the Sundance at the injector well. If the Sundance is saline (above 10,000 mg/L TDS) then High Plains may amend this permit application to include the Sundance as a sequestration interval. If Sundance water has TDS concentrations below 10,000 mg/L then the interval will be monitored as the lowermost USDW.

***Major Aquitards:*** *Chugwater and Goose Egg—proposed upper confining intervals*

The Triassic Chugwater confining unit consists of red siltstone and shale with a few purple, yellow, and green siltstone beds; it also contains beds of gypsum, sandstone, and limestone. The Goose Egg confining unit is composed of red sandstone and siltstone with interbeds of white gypsum, halite, and purple to white dolomite and limestone (Love and Christiansen 1985). These zones, which are present across the EWS Hub AoR and act as the overlying confining units to the Lyons Formation, are not aquifers and thus are not USDWs.

***Sandstone Saline Aquifer:*** *Lyons Formation—proposed injection interval*

The hydraulic role of the Lyons Formation was not identified in the 2013 WWDC report. However, High Plains analyzed regional data from the USGS National Produced Waters Geochemical Database[7] and found strong trends of salinity increasing with depth and along the eastern flank of the basin. Freshwater only exists along the western edge of the DJ Basin, where meteoric recharge plays a dominant role, with salinity increasing to the east due to the presence of evaporites and brines in the Paleozoic section (Figure 2.12). Mapped TDS concentrations of Lyons Formation fluid (Section 2.3.6, Figure 2.16) estimate the EWS Hub location to have approximately

[7] *retrieved at*: https://www.usgs.gov/data/us-geological-survey-national-produced-waters-geochemical-database-v23

224,000 mg/L TDS, classifying the Lyons as highly saline to brine formation water. The Lyons therefore does not meet the criteria of a USDW.

***Major Aquitard:*** *Satanka Formation—proposed lower confining unit*

The Early Permian Satanka Formation confining unit consists of silty red shale and siltstone interbedded with fine-grained sandstone, gypsum, and anhydrite beds (Taucher et al. 2013). As the Satanka Formation is not an aquifer it does not meet the criteria of a USDW.

***Paleozoic Aquifers:*** *Casper, Hartville, Guernsey, and Freemont Canyon aquifers*

Potential Paleozoic aquifers of the DJ Basin and Hartville Uplift include the Casper, Hartville, Guernsey, and Freemont Canyon Formations. These older carbonate aquifers are composed primarily of limestone and dolomite and have sporadic water development due to variation in water yield and quality (Taucher et al. 2013). Reservoirs associated with fresh Paleozoic aquifer production are not anticipated to be present at the EWS Hub and thus not anticipated to be USDWs.

Brendecke and Hinckley also conclude in their 2014 Hydrogeologic Study of the Laramie County Control Area that the top of the Pierre Shale represents the base of the groundwater model, therefore older Paleozoic aquifers are not included within the groundwater model boundary. Suggested Wyoming nomenclature is used for the hydrologic overview of the area when referencing potential Paleozoic aquifers identified by the WWDC. These descriptions and interpretations are strongly supported by surface exposures and outcrops located near areas of recharge with Paleozoic aquifer potential. Increased oil and gas activity to the south advanced Colorado's regional insight into subsurface Paleozoic formations and has been instrumental to High Plains' regional understanding of Paleozoic formations. Paleozoic intervals are anticipated to occur at greater than 9,300 ft below ground surface at the EWS Hub. Thus, High Plains will refer to Colorado Paleozoic vernacular for all purposes of this application other than hydrologic differentiation. A comparison of the two nomenclatures was displayed in Figure 2.3.

***Major Aquitard:*** *Precambrian basement confining unit*

This Precambrian basal confining unit consists of undifferentiated igneous and metamorphic rocks of the Precambrian basement, including metasedimentary and metavolcanic rocks. This unit acts as a basal confining unit on a regional scale by laterally hydraulically separating aquifers and therefore is not designated as a USDW (Taucher et al. 2013).

#### *2.2.1.1 Summary of USDWs*

Following the review of potential major aquifers, minor aquifers, marginal aquifers, and aquitards identified in the 2013 WWDC Platte River Basin Water Plan Update (Plate M; Taucher et al. 2013), the following hydrogeologic units are confirmed as USDWs in the area of the EWA Hub:

- Quaternary alluvial and terrace deposits
- "High Plains Regional Aquifer System" or "Tertiary Aquifer System"
- Ogallala, Arikaree, and White River formations
- Lance and Fox Hills formations

These confirmed USDWs are consistent with the findings of the 2014 Wyoming State Engineer's Office (WSEO) and 2021 USGS studies (Brendecke and Hinckley 2014; Bartos et al. 2021). While a Class II permit application recently approved in Laramie County for Samson's Lasso SWD [API# 49-021-29393] designated the Fox Hills as the lowermost USDW in other areas of the county the Cretaceous Muddy Sandstone has received aquifer exemptions from the US EPA for Class II water disposal—only necessary if the formation meets the EPA's criteria of a USDW. Confirmed USDW aquifers are summarized in the stratigraphic column in Figure 2.12 while deeper potential USDW aquifers, with unknown yields and fluid TDS concentrations which will be evaluated in future wells, are indicated.

| Era | Period | Epoch | Formation | Designation | Approx. Depth | Comment |
|---|---|---|---|---|---|---|
| Cenozoic | Quaternary | Holocene & Pleistocene | Alluvium and Terrace Deposits | Confirmed USDW | Upper Cretaceous Lance through Quaternary deposits are undifferentiated | may be present |
| | Tertiary | Pliocene | | | | absent due to erosion or nondeposition |
| | | Miocene | Ogallala | Confirmed USDW | | regional aquifer |
| | | | Arikaree | Confirmed USDW | | regional aquifer |
| | | Oligocene | White River | Confirmed USDW | | regional aquifer |
| | | Eocene | | | | absent due to erosion or nondeposition |
| | | Paleocene | | | | absent due to erosion or nondeposition |
| Mesozoic | Cretaceous | Upper Cretaceous | Lance | Confirmed USDW | | regional aquifer |
| | | | Fox Hills | Confirmed USDW | 1,056 | regional aquifer |
| | | | Pierre | Aquitard | 1,369 | confining unit (minor sandstone beds to be evaluated) |
| | | | Niobrara | Aquitard | 7,250 | confining unit |
| | | | Codell | Aquifer | 7,592 | oil and gas reservoir (TDS to be confirmed) |
| | | | Carlilie | Aquitard | | absent due to erosion or nondeposition |
| | | | Greenhorn | Aquitard | 7,758 | confining unit |
| | | | Graneros / Belle Fourche | Aquitard | 7,801 | confining unit |
| | | | Mowry / Huntsman | Aquitard | 8,126 | confining unit |
| | | Lower Cretaceous | Muddy /J Sand | Aquifer | 8,282 | oil and gas reservoir (TDS to be confirmed) |
| | | | Skull Creek / Thermopolis | Aquitard | 8,375 | confining unit |
| | | | Inyan Kara / Dakota / Lakota / Coverly | Aquifer | 8,451 | tight sand (TDS to be confirmed) |
| | Jurassic | Upper Jurassic | Morrison | Aquitard | 8,650 | minor aquifer not present, only confining unit |
| | | Middle Jurassic | Sundance | Aquifer | 8,804 | probable saline aquifer (TDS to be confirmed) |
| | Triassic | Upper Triassic | Chugwater | Aquitard | 8,899 | confining unit |
| | | Lower Triassic | Goose Egg | Aquitard | 9,178 | confining unit |
| Paleozoic | Permian | Upper Permian | Lyons | Aquifer | 9,447 | confirmed saline aquifer |
| | | Lower Permian | Satanka | Aquitard | 9,512 | confining unit |
| | Pennsylvanian | | Casper / Hartville >> Wolfcamp | Aquifer | 9,812 | probable saline aquifer |
| | Mississippian | Lower Mississippian | Guernsey >> Amazon | Aquifer | 9,843 | probable saline aquifer |
| | Devonian | Upper Devonian | Freemont Canyon >> Council Grove | Aquifer | 9,952 | probable saline aquifer |
| Precambrian | | | undifferentiated igneous / metamorphic rocks | Aquitard | 9,553 | basal confining unit |

Figure 2.12—Designation of the potential hydrogeologic units in Laramie County, Wyoming, DJ Basin.

### *2.2.2 Regional Groundwater Flow*

Groundwater in Platte River Basin aquifers flows from areas of recharge toward structural basin lows. Annual Paleozoic aquifer recharge is shown in Figure 2.13, illustrating that recharge is greatest in uplifted and highland areas of southeastern Wyoming. Recharge primarily occurs in these areas for two reasons. First, the climate transitions from semi-arid in the basin to humid-alpine in the mountains, where the majority of atmospheric moisture is captured. Second, aquifers tend to exhibit increased faulting and fracturing associated with the structural uplift, and formations have the potential to be exposed at the surface. The combination of these factors allows precipitation and surface water to enter the system, which is the primary source of groundwater recharge to Platte River Basin aquifers (Bethke and Lee 1994; Taucher et al. 2013).

Consequently, recharge of the Lyons Formation primarily takes place in the Laramie Mountains and has a general flow direction of west to east, toward structural basin lows. Figure 2.14 was modified from Bethke and Lee (1994), illustrates potential groundwater recharge and flow within the Lyons Sandstone in the DJ Basin.

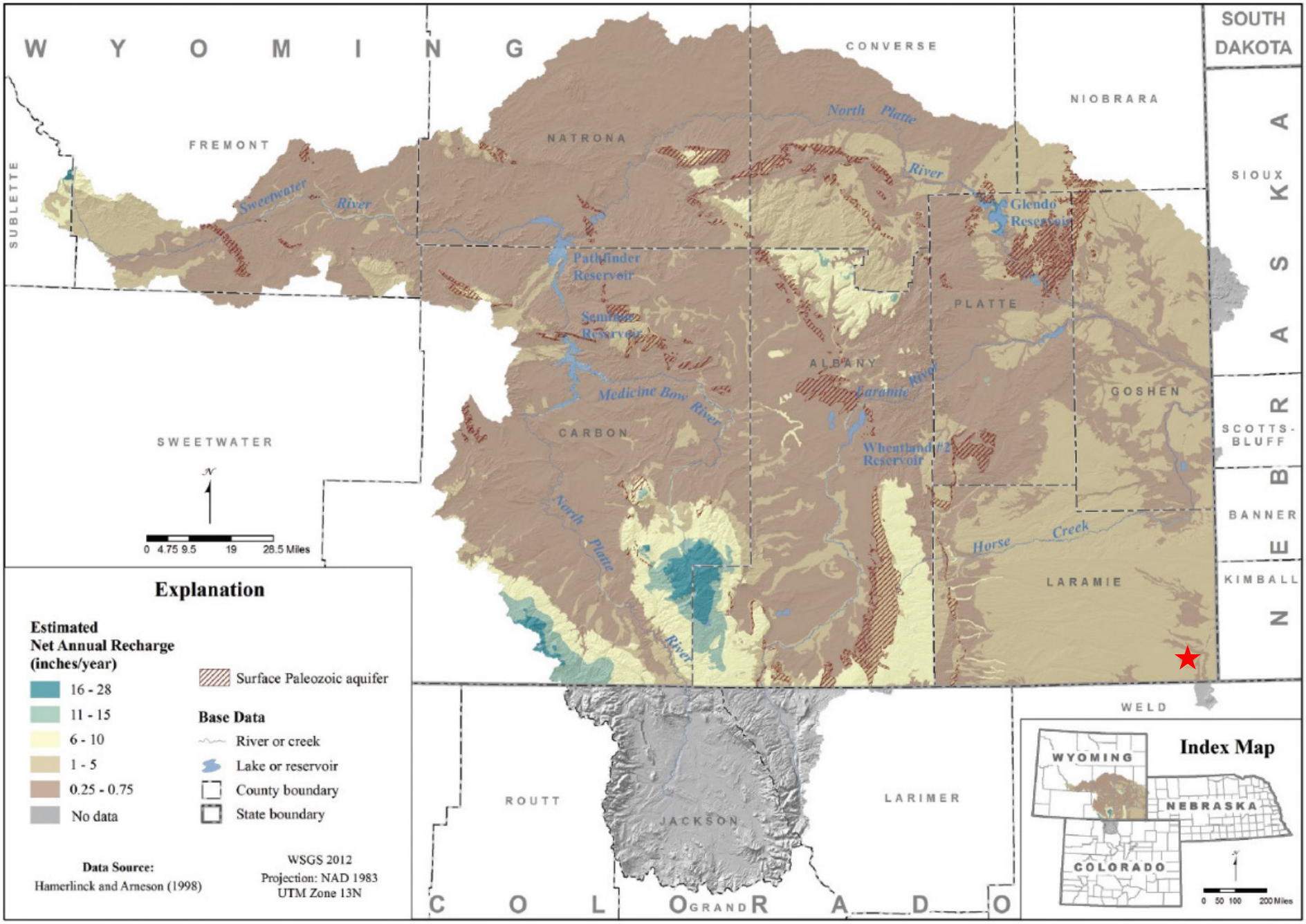


Figure 2.13—A map of the estimated net annual aquifer recharge—surface Paleozoic aquifer in Platte River Basin, Wyoming (Taucher et al. 2013). The red star is the approximate location of the EWS Hub.

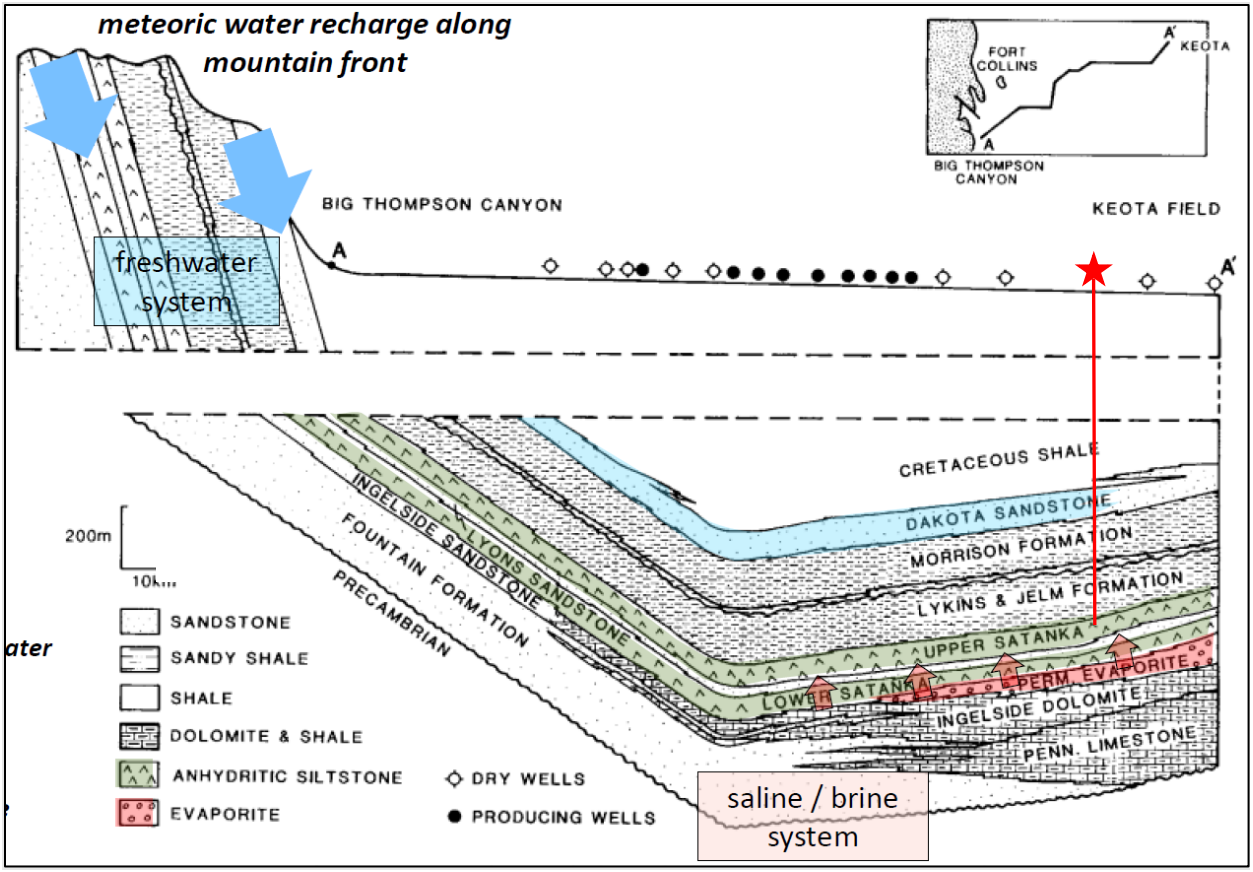


Figure 2.14—A schematic cross section through the DJ Basin, from Big Thompson Canyon to the Keota Oil Field (modified from Bethke and Lee 1994). The red star and line are the approximate location of the EWS Hub.

### *2.2.2.1 Potential Mineral Zones*

The WSGS recently developed an interactive Mineral Resources of Wyoming[8] mapping tool to improve awareness and understanding of the state's mining and mineral resources. The interactive map provides information on geology, mineralogy, chemical analyses, location, and history for a variety of mines within the state. Data contained within the interactive map is intended to help prospectors, researchers, planners, and individuals locate mining and geologic information. According to the map, 4 active (15 total) mines/quarries lie within the AoR. Historical and current mining operations of southeastern Laramie County appear to be restricted to surface mining pits. These pits tend to mine the Quaternary alluvium, Ogallala Formation, or White River Formation, depending on which formation is present at or near the surface. Surface mining operations within these intervals concentrate on the production of industrial aggregates and conglomerates.

A review of offset oil and gas activity was performed utilizing the Wyoming Oil and Gas Conservation Commission's (WOGCC) online production databases. Four oil and gas producers

[8] *retrieved at:* https://portal.wsgs.wyo.gov/arcgis/apps/webappviewer/index.html?id=e421771464634545a284784588515835

were identified within a 2.5-mile radius of the proposed Spirea I-1 location: Carpenter 126-0408H (API 49 021 21748), Carpenter 127-0429H (API 49 021 21749), Konig 2-11H (API 49 021 20838), Carpenter 523-0428H (API 49 021 21487). Carpenter 126-0408H has been producing out of the Niobrara Formation for a period of 46 months since 2019, with a total of 85,661 barrels of oil, 47,102 gas MCF, and 219,559 barrels of water reported. Carpenter 127-0429H has been producing out of the Niobrara Formation for a period of 46 months since 2019, with a total of 77,541 barrels of oil, 49,035 gas MCF, and 241,320 barrels of water reported. Konig 2-11H produced out of the Niobrara Formation for a period of 68 months from 2013 to 2020, with a total of 12,034 barrels of oil, 6,107 gas MCF, and 35,874 barrels of water reported. Carpenter 523-0428H has been producing out of the Codell Sand for a period of 46 months since 2019, with a total of 92,151 barrels of oil, 55,744 gas MCF, and 169,595 barrels of water reported.

High Plains anticipates encountering the base of Muddy J Sand at approximately 7,775 ft and the top of the Lyons Sandstone at approximately 8,950 ft true vertical depth (TVD). These depths were projected based on offset mapping and suggest that 1,175 ft of geologic section separates the Lyons Formation from the base of known hydrocarbon-productive intervals in the area. Approximately 850 ft gross section is anticipated to be impermeable and will act as an aquitard or upper confining layer. Therefore, the proposed injection interval is not anticipated to degrade or decrease the future ability to develop mineral resources within the proposed Spirea I-1 site. Figure 2.15 shows the area covered by the EWS Hub storage facility.




Figure 2.15—Map of the EWS Hub storage facility.

High Plains has identified all surface owners, mineral owners, lessees, and operators within a one-mile area around the $CO_2$ plume and area of review extent. High Plains is currently working to secure the pore space leases in the EWS Hub area. A full listing of the mineral owners, surface owners, and operators within the one-mile buffer area is provided in *Appendix A*.

## 2.3 Data and Information Sources

Characterization of the Lyons Sandstone injection interval and associated confining units was performed to model suitability of the formations to store and contain the injection of carbon dioxide. The characterization and eventual modeling were built on a series of data sets described in *Section 2.3.1*.

### *2.3.1 Existing Data*

Sedimentary strata of the DJ Basin have been studied extensively due to the basin's long history of hydrocarbon production. Existing data sets provided High Plains with sufficient preliminary data to integrate, model, and evaluate the potential capability of reservoirs within the basin to sequester carbon dioxide. Existing data utilized in the preparation of this Class VI permit application include the following:

- Regional and reservoir-specific publications
- Geophysical well logs
- 2D seismic surveys
- Offset Lyons core samples
- Formation temperature and pressure from offset drill stem test (DST) data
- Fluid analysis

#### *2.3.1.1 Regional and Reservoir-Specific Publications*

Regional and reservoir-specific studies were located, reviewed, and referenced for initial reservoir selection and characterization. Publications from the USGS, WSGS, and WSEO were particularly helpful resources in the geologic and hydrostratigraphic evaluation of the EWS Hub. A comprehensive list of incorporated studies is located in *Section 2.5*

### *2.3.2 Geophysical Well Logs and Petrophysical Analysis*

Offset geophysical well logs were interpreted to improve the geologic understanding that was initially built from literature. Formation tops picked from well logs were used to generate regional and local maps and cross sections, and to assist the petrophysical analysis of critical offset wells. This enables High Plains to effectively evaluate potential injection reservoirs and confining zones of the EWS Hub. Petrophysical analysis was performed on a total of 47 wells within southwest Nebraska, southeast Wyoming, and northeast Colorado, 18 of which are located within the EWS Hub area of interest (AOI). The 18 offset wells analyzed within the EWS Hub AOI are provided in *Appendix B*. An example of an offset open-hole log for the Foundation Energy Enderson No. 31-14 (API# 05-123-31745) is shown in Figure 2.18.

### *2.3.3 Core Sample Analyses*

Prior to the Juniper M-1 characterization well, no core analyses were available within the AoR so an extensive coring program was developed as part of the Juniper M-1 drilling program. Conventional core was cut from 8,485 to 9,268 ft MD covering the Chugwater, and Goose Egg (upper confining zone), the Lyons (injection zone) and Satanka (lower confining zone). Core analyses include routine core analysis (porosity, permeability, grain density, water saturation), the results of which have been integrated into the static geologic model. Mercury Injection – Capillary Pressure (MICP) measurements were made on 23 samples to quantify seal capacity of the confining zone and pore throat size distribution and permeability of the injection zone. Core samples were sent to specialized labs to quantify mechanical properties of the confining and injection zone. These data will be integrated into the static and dynamic models as the data become available.

### *2.3.4 Formation Temperature and Pressures*

Existing reservoir pressure data was unavailable within the AoR prior to Juniper M-1 being drilled. High Plains has since run pressure gauges in the Juniper M-1 monitoring well and recovered a reservoir pressure gradient of 0.344 psi/ft within the Lyons Formation. The pressure gauges across the Sundance Formation failed and as a result High Plains intends to collect additional pressure data across the zone in the Spirea I-1 injection well. Until new data is collected, a proposed Sundance reservoir pressure gradient of 0.25 psi/ft is used. This value is derived from the nearest drill stem test (DST) pressure gradient from the IHS database. Well Nickols #1 (API# 26-165-05005) estimated the pressure in the Sundance Formation at 0.225 psi/ft. High Plains rounded this value to 0.25 psi/ft.

Formation temperatures were gathered from measured bottom hole temperature reported in well log headers. The findings provided High Plains with the necessary inputs to calculate temperature and pressure gradients, all of which are summarized in Table 2.2 and Table 2.3, respectively.

Table 2.2—Formation temperature measurements and calculated temperature gradients for the Sundance and Lyons formations.

| Formation | Test Depth (MD, ft) | Mean Temperature (°F) | Temperature Gradient (°F/100 ft) |
|---|---|---|---|
| Sundance | 8,532 | 253 | 2.07 |
| Lyons | 9,142 | 265 | 2.07 |

Table 2.3—Formation pressure measurements and calculated pressure gradients for the Sundance and Lyons formations.

| Formation | Test Depth (MD, ft) | Formation Pressure (psi) | Mean Pressure (psi) | Gradient (psi/ft) |
|---|---|---|---|---|
| Sundance | 8,532 | 2,133 | 2,133 | 0.25 |
| Lyons | 9,142 | 3,108 | 3,108 | 0.34 |

The first permeable zone above the confining layer, the Sundance Formation, is separated from the Lyons Sandstone by roughly 500 ft of confining intervals of the Chugwater Formation and Goose Egg group. At the Spirea I-1 the Lyons pressure gradient is expected to be 0.34 psi/ft (which was measured in the Juniper M-1 characterization well) compared to the anticipated Sundance pressure of 0.25 psi/ft. This contrast in pressure suggests the units are not in geologic communication and no artificial conduits allow for crossflow in the vicinity Juniper M-1. This further supports the Goose Egg and Chugwater formations as regional seals providing robust isolation for fluids within the injection zone.

A geocellular model was constructed in southeast Wyoming. The model domain is 40 miles by 70 miles, consisting of 14 million 500 ft by 500 ft cells in the IJ plane. Initial mapping was conducted by picking formation tops of available geophysical well logs to generate structure and isopach maps. Initial regional maps were subsequently confirmed and improved by incorporating 2D seismic observations. Seismic interpreted surfaces of the Dakota, Morrison, Sundance, Chugwater, Lyons, and Satanka were then tied to the various zones within the model. Petrophysical analysis was run on 47 wells within the region, including the Juniper M-1 characterization well. Porosity and permeability were then upscaled and a geostatisticly distributed across the model domain.

### *2.3.5 Microfracture Tests*

No microfracture data could be obtained from publicly available sources near the EWS Hub location. The fracture gradient will be confirmed in Spirea I-1 (Table 2.4) prior to injection. The models will be updated to reflect site-specific data once additional data is collected.

Table 2.4—A description of the microfracture tests (awaiting step-rate test analysis from Spirea I-1).

| | | Breakdown Pressure | | Propagation Pressure | Closure Pressure | | Initial Shut-In Pressure | |
|---|---|---|---|---|---|---|---|---|
| Formation | Test Depth (ft) | Gradient (psi/ft) | Avg. (psi) | Gradient (psi/ft) | Avg. (psi) | Gradient (psi/ft) | Avg. (psi) | Gradient (psi/ft) |
| Goose Egg | - | - | - | - | - | - | - | - |
| Lyons | - | - | - | - | - | - | - | - |
| Satanka | - | - | - | - | - | - | - | - |

### *2.3.6 Fluid Samples*

High Plains collected fluid samples in the Lyons Formation from the Juniper M-1 characterization well. Additionally, formation fluid analyses from USGS and WSGS publications for all relevant formations present at the EWS Hub were also collected and analyzed. Samples for the White River, Lance, and Fox Hills formations (all shallow confirmed USDWs) were collected from three USGS monitoring wells located approximately eight miles southeast of the EWS Hub. The monitoring wells are near each other and can be referenced by their USGS site-identification numbers (410233104093201, 410233104093202, 410233104093203). The TDS concentration values for the White River, Lance, and Fox Hills formations are included in Table 2.5 along with associated sample depth (Bartos et al. 2021). The Hygiene member of the Pierre shale is present at the Juniper M-1 location at a depth of approximately 4,319 ft, but no water samples were taken or analyzed.

Niobrara, Carlile, and Muddy values were obtained from the findings of the 2020 WSGS report, Groundwater Salinity in Wyoming (Taboga and Stafford 2020)[9]. The study compiled and reviewed more than 11,500 records of water quality analysis in Wyoming with reported TDS values. The study averaged available datapoints for Cretaceous producing geologic units from 101 Niobrara samples, 26 Carlile samples, and 30 Muddy samples. The reported TDS averages for the Niobrara, Carlile, and Muddy formations are included in Table 2.5 along with associated well count for each formation. The data reported in Table 2.4 were derived from multiple sources including: the USGS, WOGCC, and samples collected from High Plains from the Juniper M-1 well. Assumptions used in the TDS analysis were drawn from the public sources as well as from the analyzed samples recovered from the Juniper M-1 well. Taboga and Stafford (2020) states:

> *"The USGS Produced Water Database (USGS 2018) and the WOGCC Water Analysis Database (WOGCC 2018) do not specify the methods used to determine TDS concentrations. It should be noted that the data from the USGS and WOGCC databases were collected by different operators over seven decades using any of the methods discussed above. The lack of strict quality control may have biased some of the statistical analyses presented in this report.*
>
> *"Salinity levels were charted against corresponding depth data in scatter plots for each stratigraphic unit with 10 or more samples. First, all plotted data were evaluated by application of the Linear Regression analysis tool in the Microsoft Excel Analysis ToolPak. Scatter plots that displayed a coefficient of determination (R2) greater than 0.30 were then visually examined* for data point clusters, outliers, and non-linear trends that could exert disproportionate influence on R2 (Anscombe 1973). Statistical significance was assigned to qualified datasets where p-values <0.05. Plots with apparent non-linear trends (Brown 2000) were evaluated with the Generalized Reduced Gradient algorithm in the Excel Solver platform by minimizing the difference between model estimates and observed salinities.*"*

[9] A copy of this report can be obtained here: https://www.wsgs.wyo.gov/products/wsgs-2020-ofr-10.pdf.

Water samples from the Lyons Formation were acquired from the Juniper M-1 well using SLB's Slimline Single-Phase Reservoir Fluid Sampler (SRS) tool (analyses provided in *Appendix C*). The SRS tool maintains samples in a single-phase condition as the tool is retrieved from the borehole. The collected samples are brought to the surface at in-situ pressure conditions. Technical specifications for the SRS tool are provided in *Appendix E*.

The following is a summary of the Lyons fluid sampling procedure in the Juniper M-1 characterization well:

- After the well had been drilled, cased, and the 5-1/2 in. casing cemented, the final cement displacement was done with 9.8 ppg brine. After final cementing operations were completed, the drilling rig was released and was replaced by a smaller workover rig. The well was cleaned out to total depth and the service company ran the USIT pipe and cement evaluation logs for the 5-1/2 in. casing. Prior to the Lyons water sampling operations, the rig ran a tubing workstring to 4,086 ft and unloaded the well with nitrogen, reverse circulating the brine to the rig tank. The wellbore pressure was expected to be 630 psi underbalanced to the Lyons formation based on internal pressure gauge compared to the expected reservoir pressure. The service company perforated the Lyons formation in the interval 9,165 to 9,171 ft, in the 9.8 ppg brine. Perforating occurred underbalanced, with the internal pressure gauge increasing 250 psi after perforating. The brine fluid level in the well was detected at 4,020 ft.
- The rig subsequently ran in hole with a compression-set testing packer on 2-7/8 in. tubing workstring to 7,982 ft, which was set to isolate the perforations from the upper wellbore. The well was swabbed 13 runs, recovering 55 barrels of brine and water from the formation. Samples collected every 15 barrels shows variations in electrical conductivity, pH, and specific gravity, however the readings were not reported in the rig reports. The sandline parted while making run number 14. The packer had to be unseated and the tubing and packer pulled to surface to recover the fish, as reported on the Daily Completion Report dated 06/30/2023, for operations the previous day.
- On 06/30/2023 (report of 07/01/2023), a new compression-set testing packer was made up and run on the workstring. The packer was set at 7,980 ft and swabbing operations resumed. Eight (8) swabbing runs were made, recovering 35 barrels of effluent brine or water from the Lyons Formation. The completion report states that total of 90 barrels of fluid was unloaded from the Lyons Formation during the two days of swabbing. The daily completion report states that field water samples showed stabilized electrical conductivity, pH, and specific gravity values, but specific values were not reported.
- On 07/03/2023 (report of 07/04/2023), SRS samples were collected on wireline but specific depth of collection are not reported in completions report.
- Based on the narrative of the well operations prior to and during sampling, it is not reasonable or possible to claim that water samples obtained are truly from and representative of the Lyons Formation. Although the well was partially unloaded with nitrogen to an underbalanced state, perforating in brine and, the surging effects of running in hole with the test packer on tubing will likely push high salinity 9.8 ppg brine into the perforations. The parted sandline during the first day of swabbing and the need

to pull and rerun the tubing and test packer would most certainly cause additional surging effects that could push brine into the perforations and formation. The type of brine used for cement displacement is not mentioned in the daily rig reports and it is not known whether it was the calcium chloride brine used for mixing the oil-based mud for drilling the well.

- A review of the daily drilling and completion reports shows there is a possibility that the Lyons Formation water sample collected could be contaminated from brine present in the wellbore at the time of sampling. High Plains will collect additional fluid samples in the Lyons Formation in the Spirea I-1 prior to injection.

The TDS value in Table 2.5 represents the average of all four Lyons samples analyzed, no samples were excluded. The individual Lyons fluid sample values are listed in Table 2.5. The average measured TDS of the Lyons samples is 224,933 mg/L, whereas the estimated value based on regional TDS trends utilizing sparse regional sampling from USGS National Produced Waters Geochemical Database [10] estimates the Lyons in the EWS Hub area to contain 185,000 mg/L TDS. The water samples from the Juniper M-1 well are still being analyzed for possible effects of contamination on the TDS values (described earlier in this section).

Fluid samples in the Sundance Formation, the first permeable zone above the confining layer, will be collected and analyzed in the Juniper I-1 well along with all other potential overlying USDW aquifers outlined in Section 2.2.1. High Plains will provide these data as they become available.

[10] https://www.usgs.gov/data/us-geological-survey-national-produced-waters-geochemical-database-v23

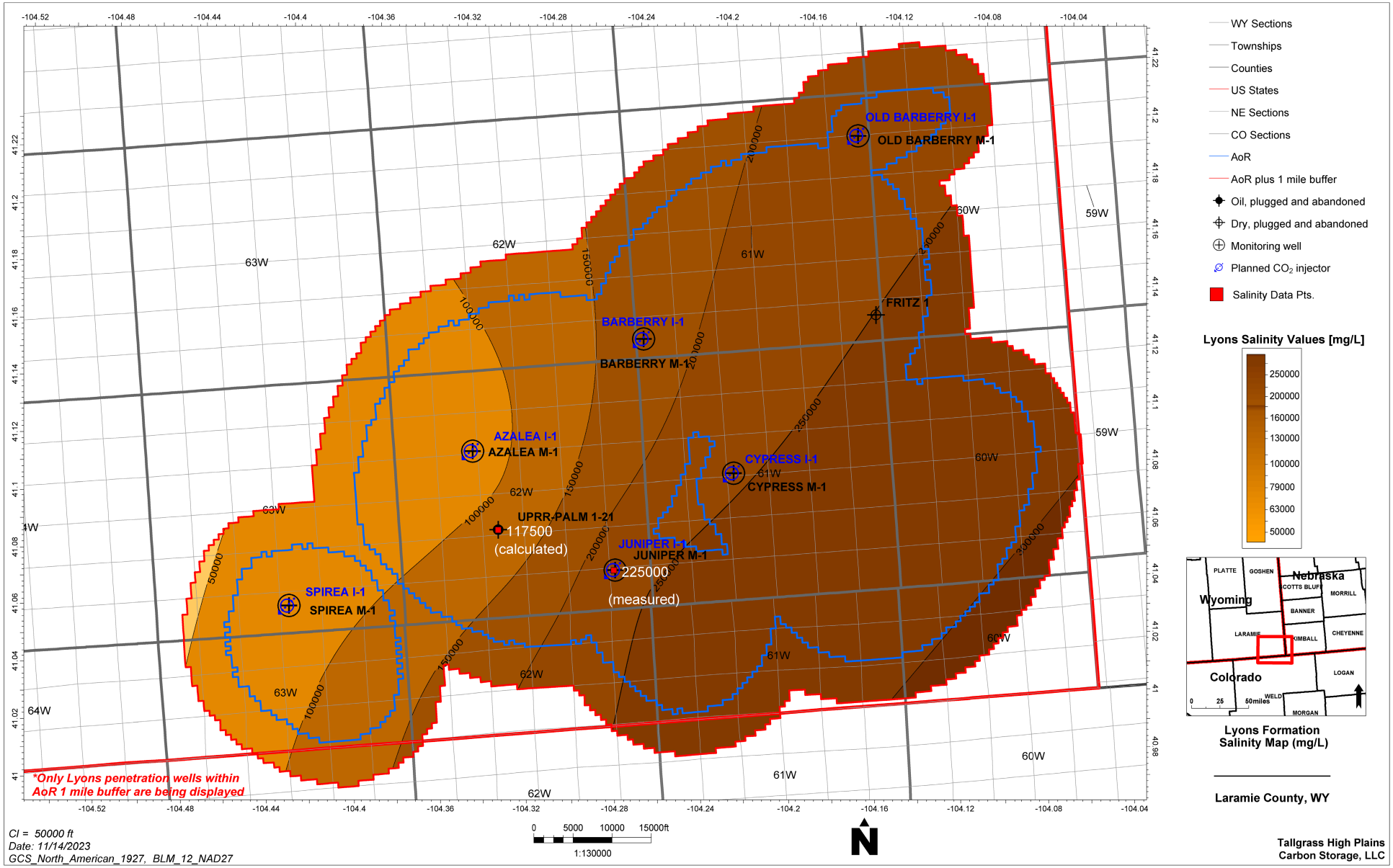


Figure 2.16—A Lyons Formation salinity concentration (mg/L) trend map within the area of review plus a one-mile buffer.

Table 2.5—Fluid sample tests and corresponding TDS concentrations for each sample.

| Formation | Test Depth (ft) | TDS (mg/L) |
|---|---|---|
| White River[1] | 54 | 373 |
| Lance[1] | 120 | 286 |
| Fox Hills (lowermost confirmed USDW)[1] | 431 | 384 |
| Niobrara[2] | average of 101 wells | mean of 39,983 |
| Carlile[2] | average of 26 wells | mean of 31,770 |
| Muddy[2] | average of 30 wells | mean of 13,856 |
| Sundance | ±8,550–8,600 | TBD |
| Lyons[3] | 9,165–9,171 | 224,933 |

[1] Bartos et al. 2021
[2] Taboga and Stafford (2020)
[3] Measured in Juniper M-1 well (see Appendix C); to be confirmed with future fluid sampling

### *2.3.7 Seismic Survey*

A review of the available 2D seismic surveys identified ten 2D lines within the EWS Hub area. These seismic data were interpreted and incorporated into the regional evaluation of the EWS Hub to confirm and improve structural mapping, locate potential faulting within the section, and validate stratigraphic interpretations within the vicinity of the EWS Hub. High Plains has access to an extensive collection of open-hole sonic log data across the Lyons Formation in Wyoming, Nebraska, and Colorado. These geophysical well logs were used to tie 60 wells to offset seismic lines resulting in high confidence in the tied phase. However, only a handful of the seismic well ties are in the immediate EWS Hub proximity.

**Planned 2D Seismic Surveys**

High Plains plans to acquire and analyze additional 2D seismic across the EWS. These data will help to refine the surface static and dynamic models and serve as indirect plume monitoring, as discussed in the Testing and Monitoring Plan (Section 4.3). Figure 2.17 displays licensed 2D seismic lines in green and planned 2D lines for monitoring in blue.

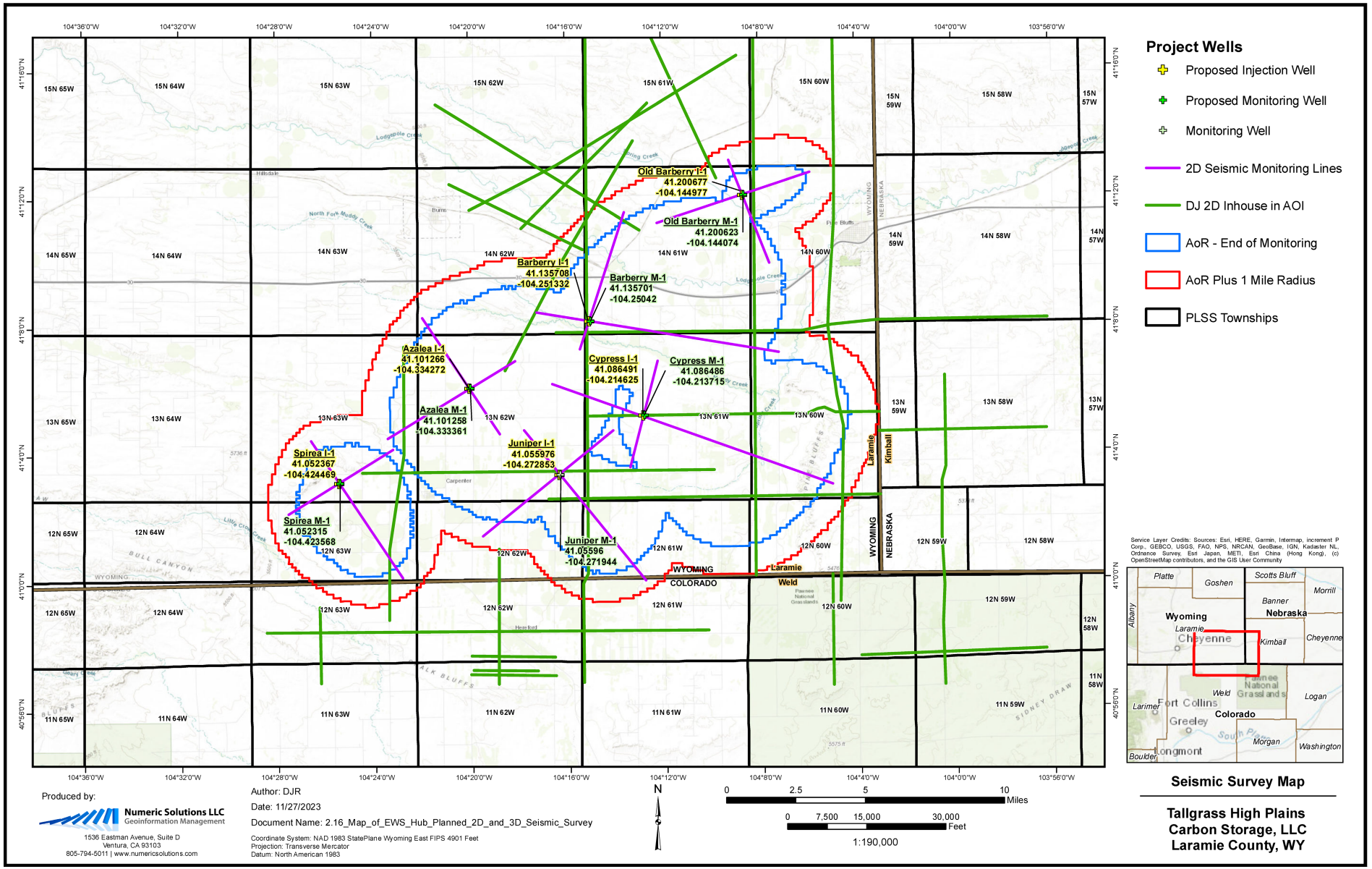


Figure 2.17—Map of the EWS Hub planned 2D seismic survey. Acquired surveys are shown in green while planned surveys are shown in purple. No faults were interpreted within the area of review on the existing 2D seismic data.

## 2.4 Site-Specific Data

### *2.4.1 Storage Reservoir (Injection Zone)*

The proposed storage reservoir for the EWS Hub is the Lyons Formation. Sonnenberg and Weimer (1981) reviewed outcrops of the Lyons section near Lyons, Colorado, and described the formation as a well-sorted, fine-grained, aeolian quartzose sandstone. Logs and core data collected in the Juniper M-1 characterization well indicates the Lyons Formation has sufficient levels of porosity and permeability to support injection of $CO_2$ (refer to *Appendix H—Petrophysical Report*) within the AoR. Modeling performed by High Plains demonstrates that the Lyons Formation is well-suited for injection due to the presence of a regional sand body with sufficient porosity and permeability encased within regionally extensive confining intervals. Representative properties of the Lyons Sandstone at the EWS Hub location are listed in Table 2.6. Figure 2.18 depicts an open-hole log from the Foundation Energy Enderson 31-14 well (API# 05-123-31745) located approximately 14 miles southeast of the EWS Hub, indicating the injection zone and confining intervals.

Table 2.6—Formations comprising the $CO_2$ storage area.

| Formation | Purpose | Average Thickness at Project Site (ft) | Average Depth at Project Site (SSTVD, ft) | Lithology |
|---|---|---|---|---|
| Chugwater | Upper Confinement | 249 | -3,280 | Interbedded silt and red shale |
| Goose Egg | Upper Confinement | 248 | -3,529 | Interbedded anhydrite and shale |
| Lyons | Injection Interval | 67 | -3,777 | Aeolian sandstone |
| Satanka | Lower Confinement | 189 | -3,843 | Interbedded silt and red shale |

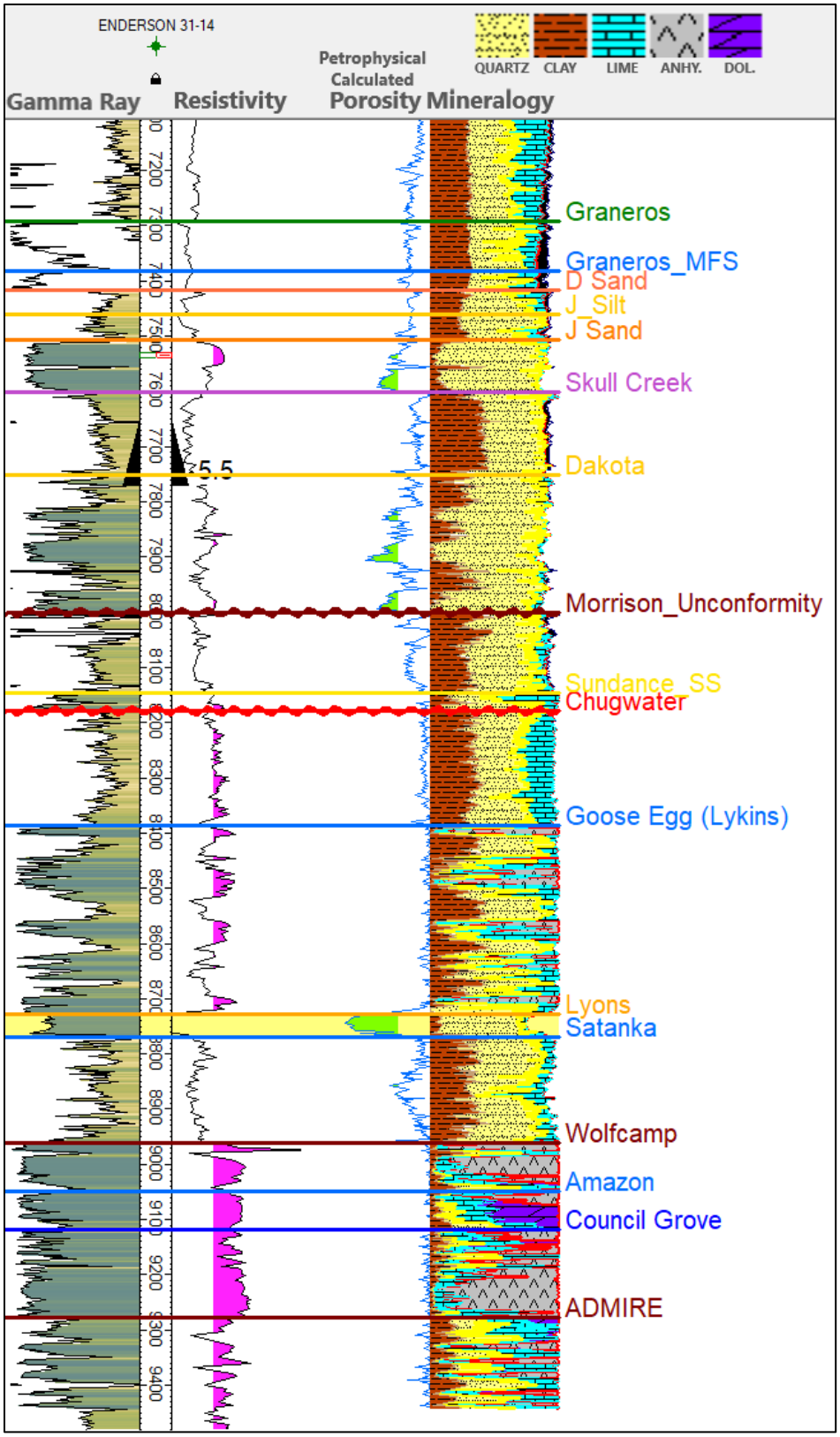


Figure 2.18—EWS Hub offset open-hole log, the Foundation Energy Enderson 31-14 well (API# 05-123-31745). The gamma ray curve is color coordinated relative to magnitude, the resistivity curve is shaded pink for values >20 ohms, and the petrophysical calculated porosity curve is shaded green for values >10%.

The Lyons Formation is generally described as an aeolian sandstone. Red beds comprise most of the sandstone and commonly contain quartz overgrowths, calcite cement, and iron oxide coating. However, lithofacies within the Lyons tend to vary due to a complex depositional environment and subsequent diagenetic cementation. Facies within the Lyons Formation can range from sandstone to evaporites, carbonate, red shale, and conglomerate. Sand development occurred on a regional high between evaporite basins that spanned parts of southwest Nebraska, southeast Wyoming, and northeast Colorado, as depicted in Figure 2.19. This resulted in the deposition of a regional sand body within the Lyons Formation that trends southwest to northeast over the EWS Hub. The Lyons Formation is anticipated to contain sandstone at the EWS Hub location with increasing evaporite content to the northwest and southeast, which will help impede lateral migration of injected $CO_2$ in those directions.

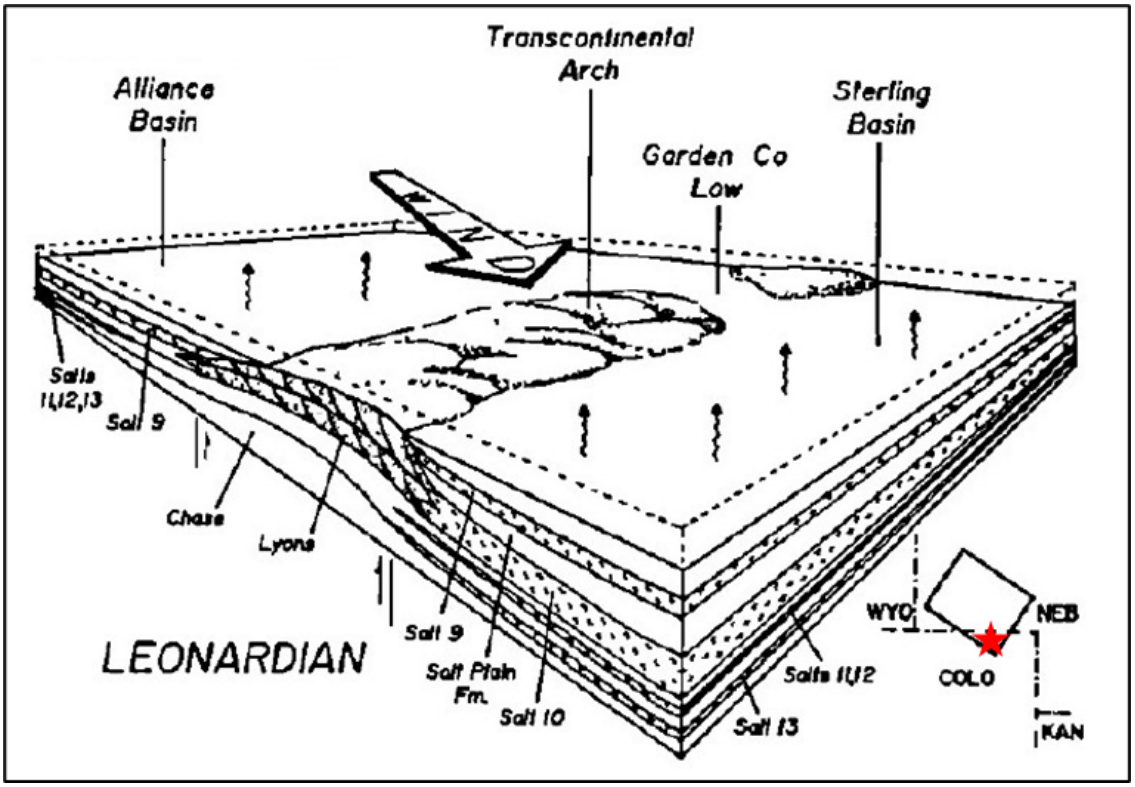


Figure 2.19—Mapped facies changes within the Lyons Formation. The red star is the approximate location of the EWS Hub (Oldham 1996).

Regional lithologic variation of the Lyons Formation is primarily due to relative positioning within the depositional environment. Bethke and Lee (1994) proposed that diagenesis also served a significant role in the alteration of the Lyons Formation following burial and compaction. Bethke and Lee (1994) also suggested that the Laramide uplift along the Front Range allowed for entry of meteoric water and eastward movement of groundwater flow. This recharged the Lyons Formation while simultaneously driving formation water deep into the basin, where salinity increased with continued exposure to evaporite sequences (Figure 2.20).

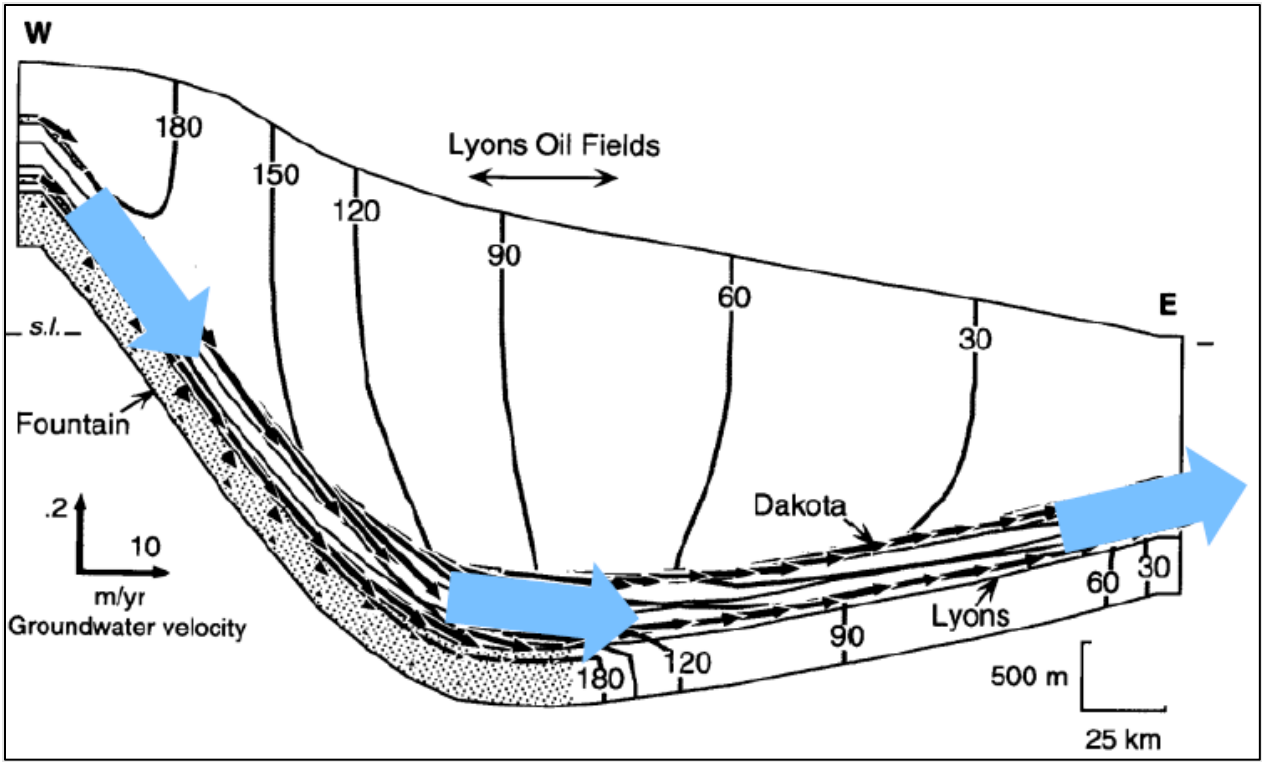

Figure 2.20—Schematic cross section depicting calculated Eocene groundwater flow (blue arrows) and hydraulic potential distribution of the DJ Basin proposed by Bethke and Lee (1994).

Regional movement of groundwater and increasing salinity allowed diagenetic alteration to remove iron oxide and calcite cements from red beds within the Lyons Sandstone, resulting in gray diagenetic facies that exhibit increased porosity and permeability. The gray diagenetic Lyons Sandstone is commonly associated with productive oil and gas fields of the Lyons Formation and represents the facies expected to be present at the EWS Hub location (Bethke and Lee 1994). However, the Lyons contains highly saline to brine formation water at the proposed Spirea I-1 location and does not contain hydrocarbon potential.

A structure map on the top of the Lyons Formation was constructed from formation tops picked from publicly available open-hole logs (Figure 2.21). To confirm the structural interpretation and improve detail of structural understanding, 2D seismic lines were reviewed. The Lyons structure strikes north-south and has a general dip to the west of approximately two degrees with a surface variation of approximately 2,000 ft within the map extents. A list of Lyons Formation tops utilized to generate the top of the Lyons structure map appears in Table 2 of Appendix I.

Offset open-hole logs were also utilized to construct a gross isopach of the Lyons Formation (Figure 2.22). The Spirea I-1 is anticipated to penetrate the Lyons at a depth of approximately -4,102 ft subsea true vertical depth (SSTVD) with a gross thickness of 50–100 ft. Observed thickness changes are likely due to key facies changes that occur when moving northwest from the EWS Hub location.

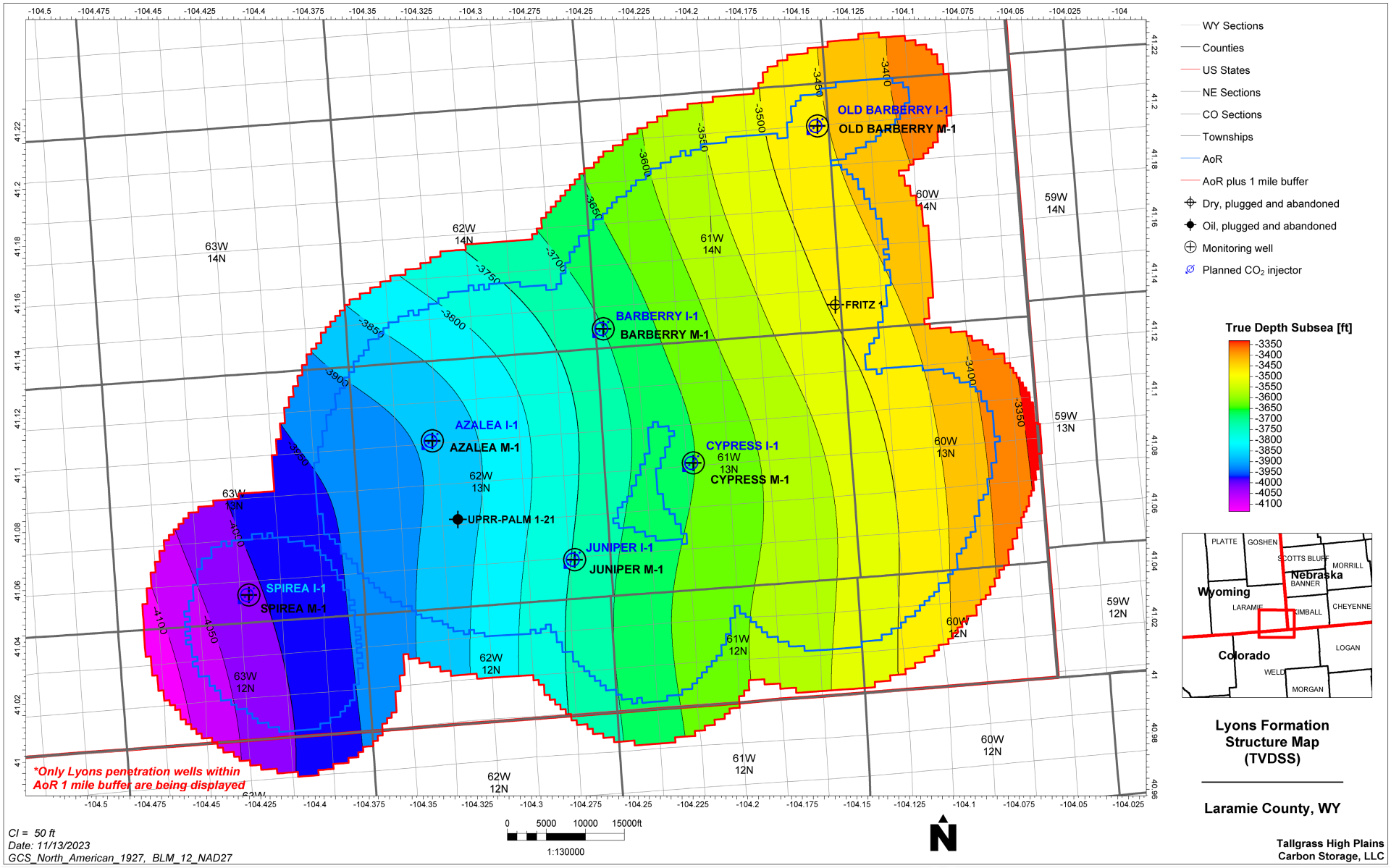


Figure 2.21—Subsea structure map on the top of the injection zone, the Lyons Formation.

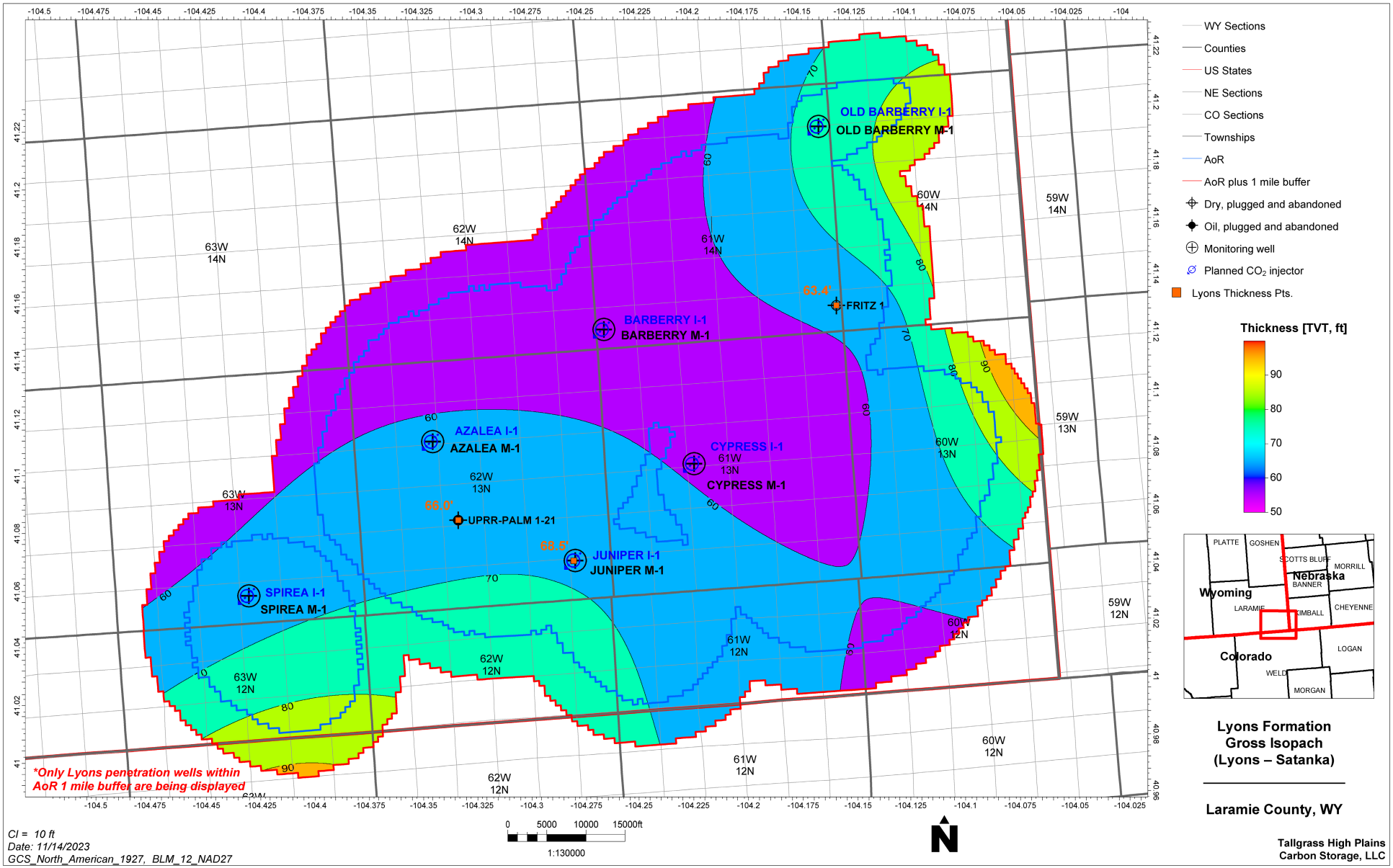


Figure 2.22—Gross isopach map of the injection zone, the Lyons Formation.

### *2.4.1.1 Vertical Distribution of Core-Derived Porosity and Permeability*

Routine core analysis was performed on the Lyons Formation in the Juniper M-1 well, as discussed in Section 2.3.3. Porosity and permeability results from core data are provided in Table 2.7.

Table 2.7—Porosity and permeability values for the Lyons Formation from core data.

| Formation | Porosity (%) | Permeability (mD) | Laboratory Analysis | Model Property Distribution |
|---|---|---|---|---|
| Lyons | 15.7 | 501 | Routine Core Analysis | Average of core samples from 9,127.7–9,185.5 ft* |

*Depths reported includes a depth shift of +10.5 ft.

Porosity and permeability distributions generated from the wells listed in *Appendix B* are displayed in Figure 2.23 and Figure 2.24, respectively. These distribution plots demonstrate that log-derived porosity and permeability values are consistent with core-derived values of the Lyons Sandstone (Table 2.7). Vertical and lateral heterogeneity are anticipated within the Lyons Sandstone due to interfingering of facies commonly associated with deposition of aeolian sands (Figure 2.25), however no significant lateral variability is observed across the AoR when comparing logs of offset Lyons penetrations. According to Kendigelen's 2016 thesis, dry dune deposits of the Lyons Formation are associated with reservoir quality sand development, and damp or wet interdune deposits are associated with lower porosities.

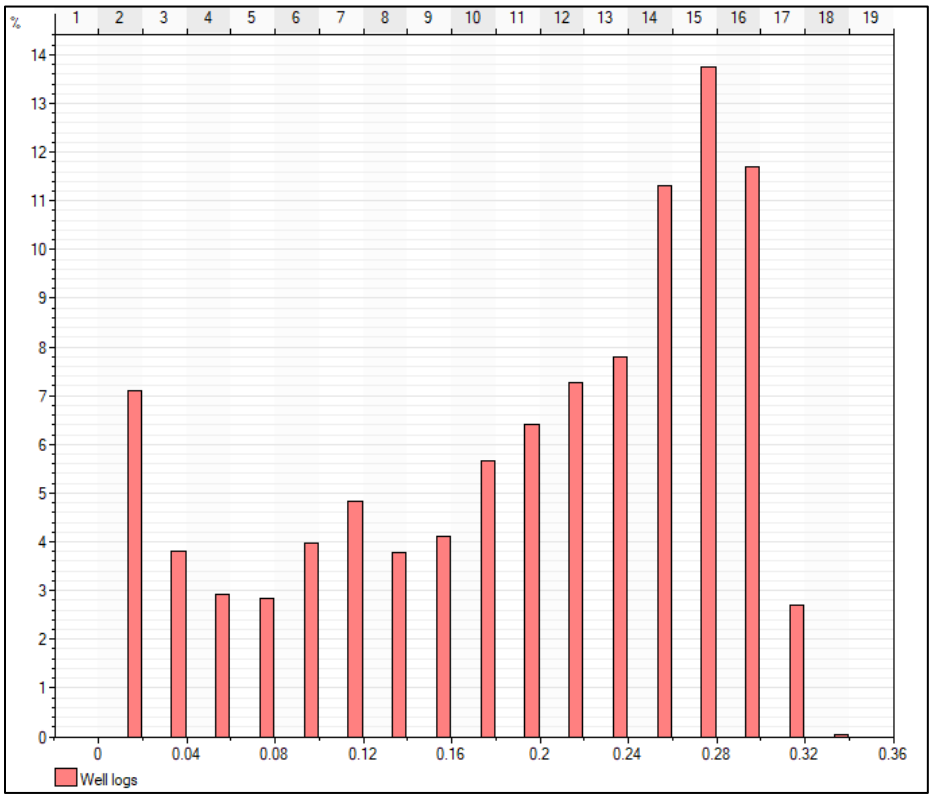


Figure 2.23—Lyons Formation total porosity (decimal) histogram generated from well logs within the static geomodel domain.

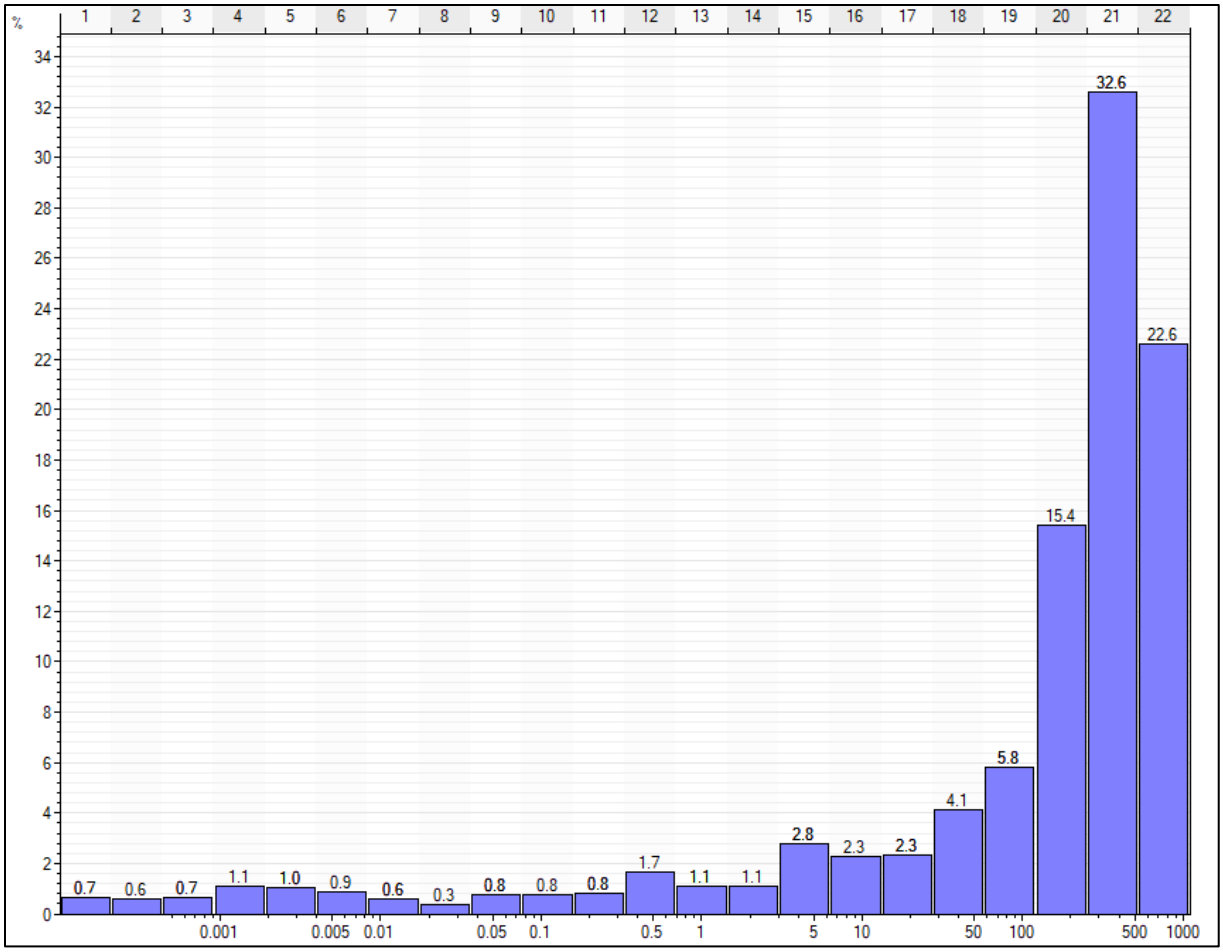

Figure 2.24—Lyons permeability (mD) histogram used in the geocellular model.

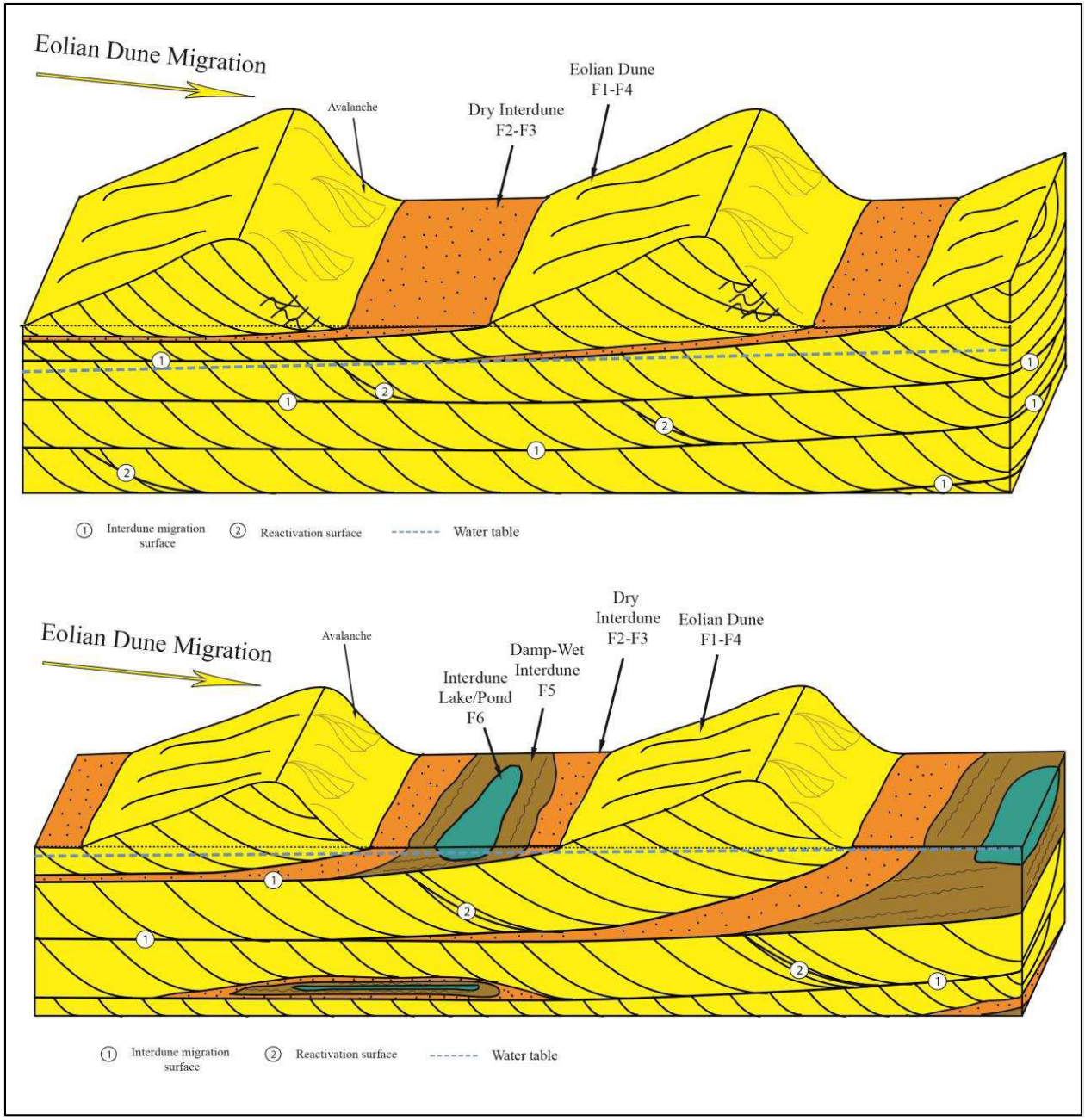


Figure 2.25—Illustration of facies deposition for the Lyons Formation (Kendigelen 2016).

### *2.4.1.2 Microfracture Data*

No microfracture data could be obtained from publicly available sources near the EWS Hub location. A step-rate test will be performed on Spirea I-1 to determine the properties of the injection interval. Models and the results shown in Table 2.8 will be updated to reflect site-specific data values once the Spirea I-1 test well data is analyzed.

Table 2.8—Storage reservoir microfracture results (to be updated for the Spirea I-1).

| Measurement | | |
|---|---|---|
| Depth (ft) | - | - |
| Pressure/Gradient | - | - |
| Breakdown | - | - |
| Fracture Propagation | - | - |
| Closure | - | - |

### *2.4.1.3 Mineralogy*

Core data gathered in the Juniper M-1 well from the Lyons Sandstone was analyzed to improve geologic understanding and modeling of the injection interval. XRD analysis was performed on 12 core plugs to help determine mineralogy within the Lyons Formation. Results from the analysis are displayed in Table 2.9 as volume percent. The XRD analysis suggests a quartz rich mineralogy with minor feldspar, low clay content and no pyrite.

Table 2.9—Summary XRD mineralogic volume percentages in the Lyons Formation from X-ray diffraction results of core data collected from Juniper M-1.

| XRD Mineralogy | Volume Percent |
|---|---|
| Quartz | 77.0 |
| Plagioclase | 4.2 |
| K-Feldspar | 6.4 |
| Calcite | 0 |
| Dolomite | 0.1 |
| Magnesite | 0.5 |
| Hematite | 0 |
| Siderite | 0 |
| Apatite | 0 |
| Gypsum | 0 |
| Anhydrite | 10.5 |
| Pyrite | 0 |
| Chlorite | 0 |
| Kaolinite | 0 |
| Illite and Mica | 1.3 |
| Mixed layer Illite-Smectite | 0.0 |
| Corrensite | 0.3 |
| Total | 100 |

### *2.4.1.4 Mechanism of Geological Confinement*

The Lyons Formation is a basin-wide interval spanning thousands of square miles. As the formation is a laterally open aquifer, there are no stratigraphic or structural traps, or spill points in the vicinity of the proposed injection project to use to define a storage area. The Goose Egg and Chugwater Formation overlay the Lyons injection zone and contain almost 500 ft of seal rock

which provides vertical confinement. Thus, the potential storage volume is primarily a function of the lateral area in which the operator desires the plume to be contained. The calculated storage volume estimated at increasing radii from the proposed injection well are provided in Table 2.10. These capacities are estimated based on a methodology after Bachu (2006) (Equation 2.1). Note, this method does not account for rock compressibility nor migration due to buoyancy; it is simply a volumetric analysis.

Equation 2.1—$CO_2$ storage volume calculation (after Bachu 2006).

$$V_{CO2} = (A \times H \times \emptyset \times (1 - Sw_{irr}) \times \rho_{CO2} \times EF) \times 10^{-6}$$

Where:

$V_{CO2}$ = $CO_2$ Storage Volume (Mt)
$A$ = area ($m^2$)
$H$ = net thickness (m)
$\emptyset$ = porosity (v/v)
$Sw_{irr}$ = irreducible water saturation
$\rho_{CO2}$ = density of $CO_2$ (reservoir conditions)
$EF$ = Efficiency Factor – defined here as the ratio of the volume of $CO_2$ injected to the net pore volume (pore volume excluding irreducible water) at the final storage pressure.

Table 2.10—Calculated potential $CO_2$ storage volumes within the Lyons Formation inside increasing radii from the proposed injection well. At a radius of approximately 1.6 miles, the Lyons Formation has the capacity to store more $CO_2$ than proposed by this Project.

| Radius (miles) | Net Thickness (ft) | Net Thickness (m) | Porosity (v/v) | Swirr (%) | Net Volume ($m^3$) | Theoretical Storage Volume (Mt) | Est. Efficiency Factor (EF) | Storage Volume (Mt) | Multiple of Anticipated Inj. Volume** |
|---|---|---|---|---|---|---|---|---|---|
| **1.0** | 64.6 | 19.7 | 0.18 | 30% | 2.02E+07 | **8.3** | 50% | **4.1** | **0.4x** |
| **1.5** | 64.6 | 19.7 | 0.18 | 30% | 4.54E+07 | **18.6** | 50% | **9.3** | **0.9x** |
| **2.0** | 64.6 | 19.7 | 0.18 | 30% | 8.07E+07 | **33.1** | 50% | **16.6** | **1.6x** |
| **3.0** | 64.6 | 19.7 | 0.18 | 30% | 1.82E+08 | **74.5** | 50% | **37.2** | **3.5x** |
| **4.0** | 64.6 | 19.7 | 0.18 | 30% | 3.23E+08 | **132.4** | 50% | **66.2** | **6.2x** |
| **5.0** | 64.6 | 19.7 | 0.18 | 30% | 5.05E+08 | **206.9** | 50% | **103.5** | **9.8x** |

*Assumes storage zone pressure of 3,212 psi and temperature of 250°F.

**Anticipated $CO_2$ Inj. Volume = 10.6 Mt

Note: does not account for change in volume due to rock compressibility;

Swirr = Irreducible water saturation, Mt = Megatonnes

Based on the calculation results, which use conservative inputs for $Sw_{irr}$ (30%) and Efficiency Factor (50%), within an approximately 1.6-mile radius of the proposed injection well the Lyons Formation has sufficient areal extent, thickness, porosity and thus storage capacity to store the anticipated volume of $CO_2$ to be injected by this project (10.6 million metric tons [MMT]). The available volume increases exponentially with distance from the injection well.

#### 2.4.1.4.1 Local Cross Sections

Local cross sections and locator maps (Figure 2.27 and Figure 2.28) have been included to help convey the geologic interpretation of the EWS Hub location and demonstrate that the injection zone has sufficient areal extent and thickness to store the planned injection volume of $CO_2$. The geologic section displayed in the cross section is limited to confining and injection intervals to provide additional clarity to regional cross sections previously shown in Figure 2.6 through Figure 2.8). Additionally, High Plains is including a well panel (Figure 2.29) that highlights the nearly isotropic nature of injection and confining zone facies, porosity, permeability, and mineralogy apparent when comparing well logs collected from across the AoR.

The geologic section demonstrates consistent structural behavior with laterally extensive confining and injection intervals present well beyond the limits of the EWS Hub.

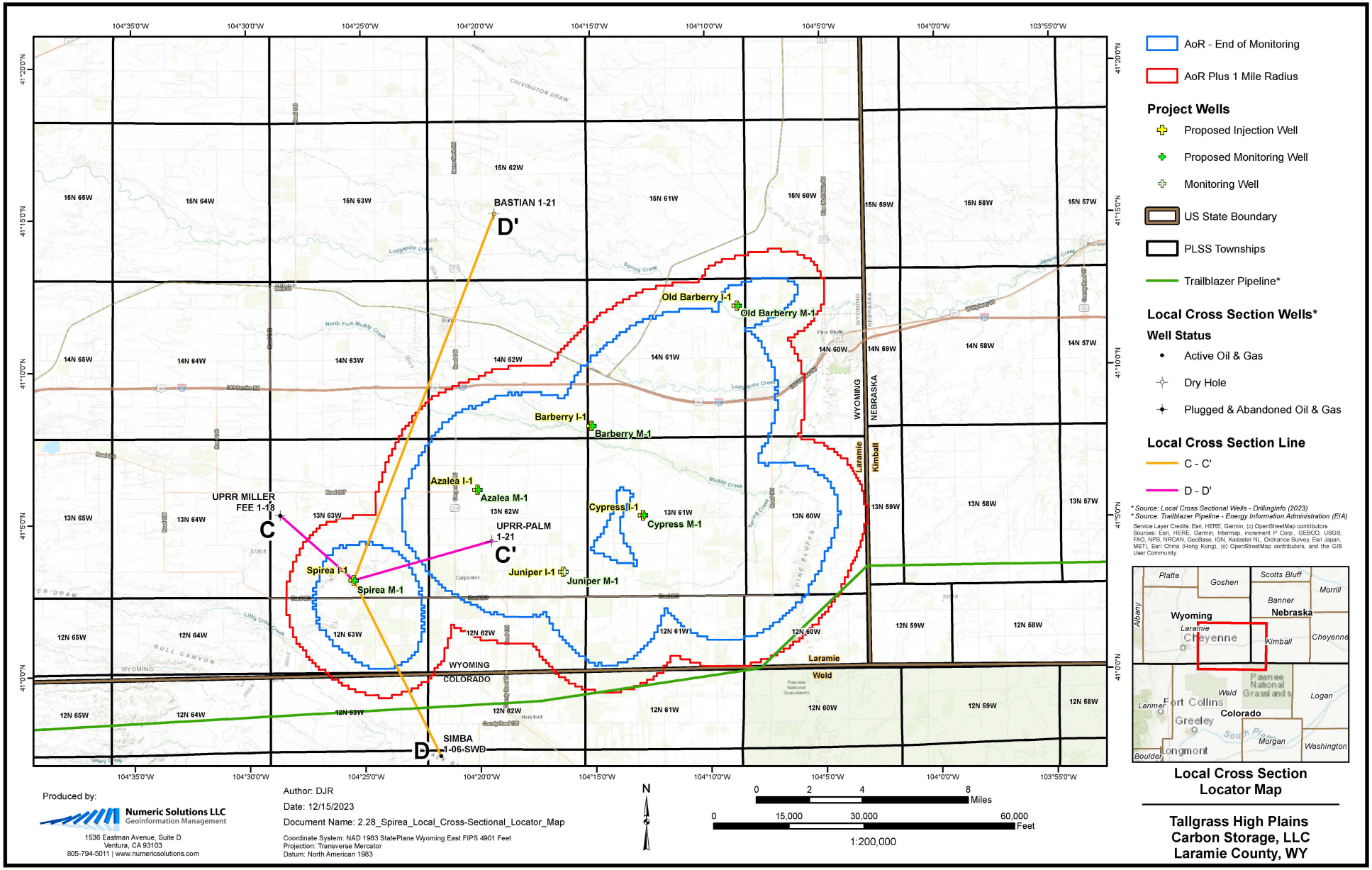


Figure 2.26—Location map of the local cross sections C-C' and D-D'.

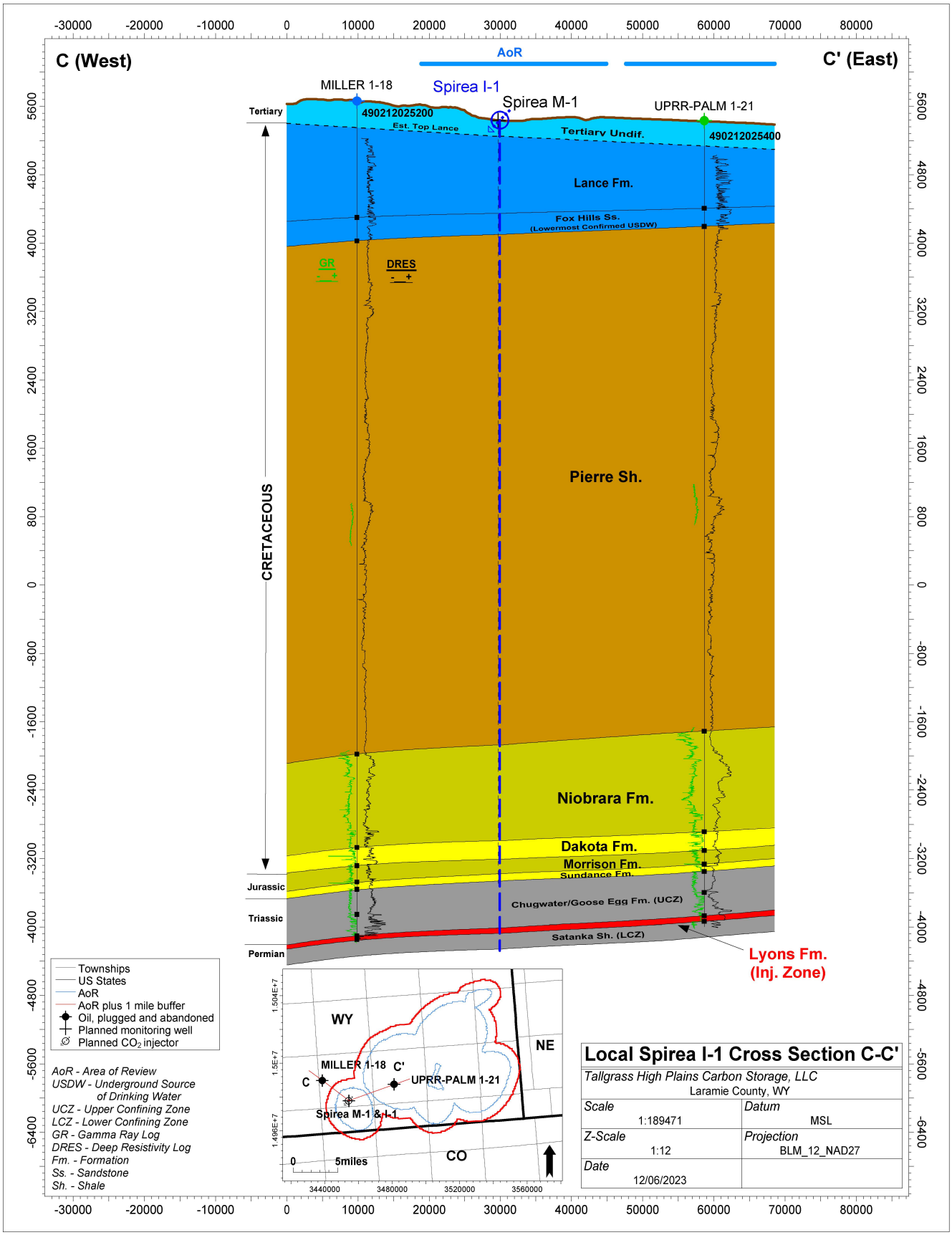


Figure 2.27—Local west-east cross section C-C’ including representative well logs outside of the area of review that cover the entire vertical dimension of the model domain.

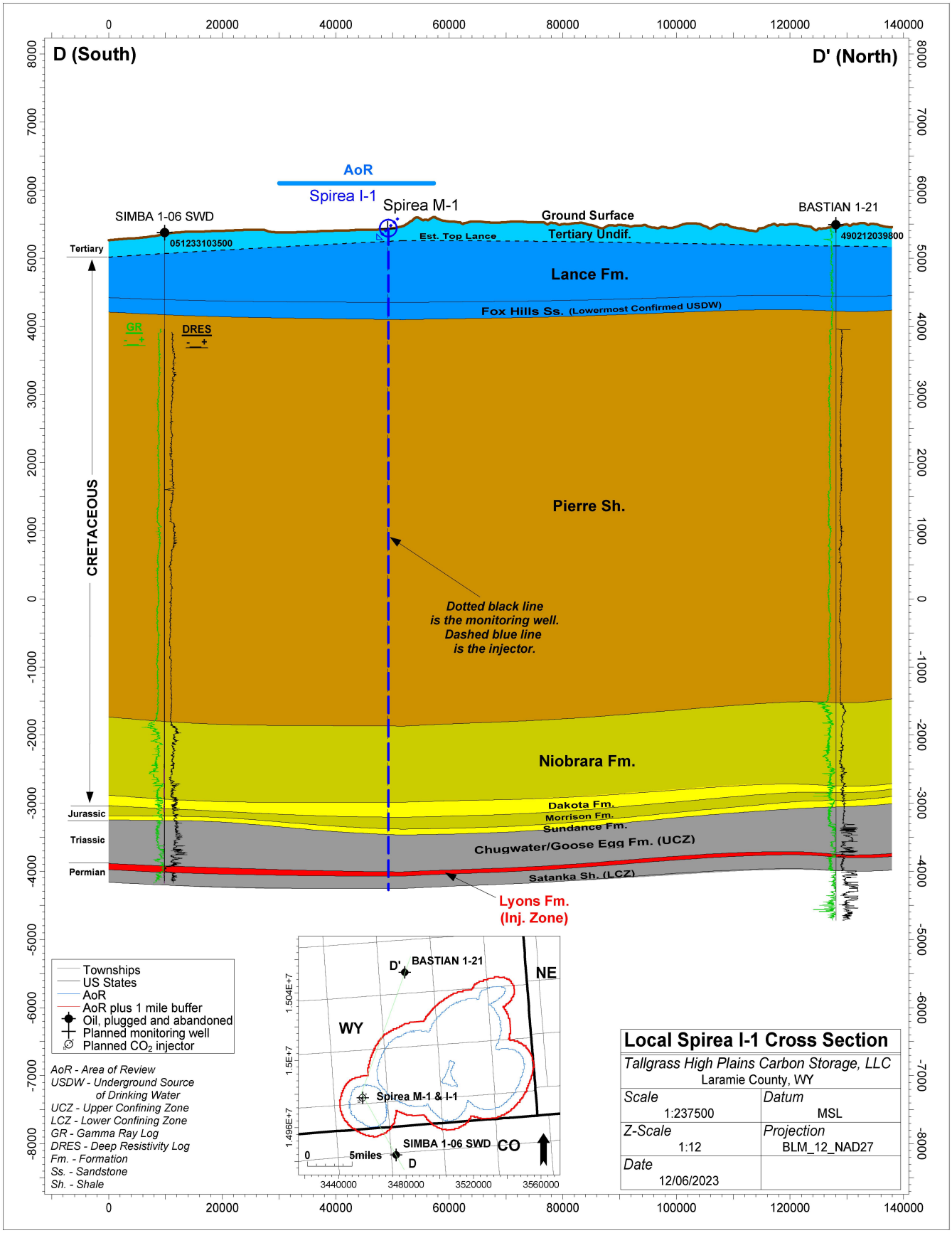


Figure 2.28—Local south-north cross section D-D' including representative well logs outside of the area of review that cover the entire vertical dimension of the model domain.

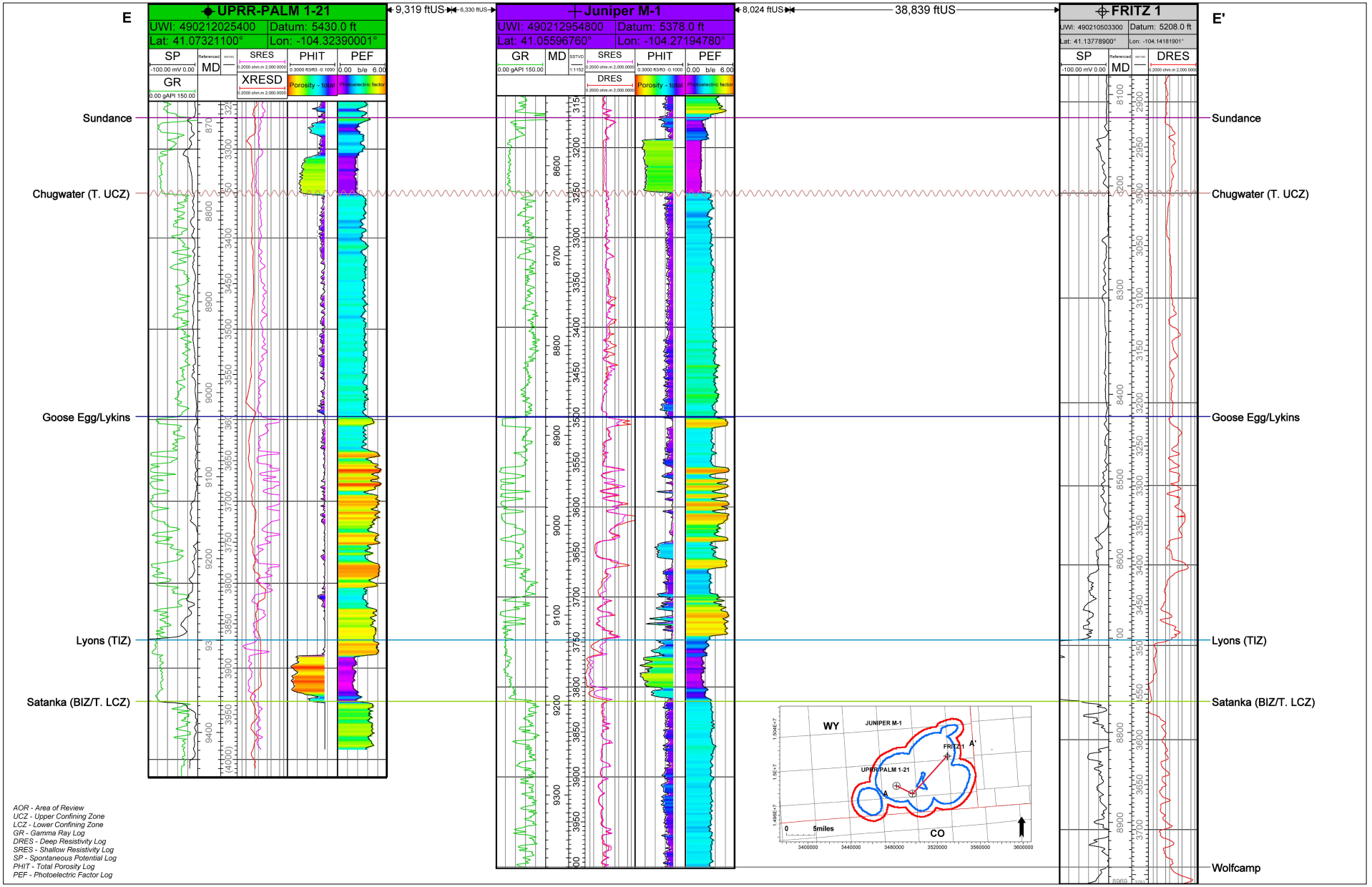


Figure 2.29—Local well panel E-E' showing the three wells within the Area of review which penetrate the injection zone. Log range and color scale values outlined in the log header.

### *2.4.1.5 Geomechanical Information of Injection Zone*

An industry standard methodology was used to determine fracture gradient of a given rock. For this method, an isotropic model was used based on the dipole sonic log recorded in Juniper M-1. Further data will be recorded in Juniper I-1 to confirm interpretation from Juniper M-1. Once additional data has been gathered, updated inputs will be incorporated into an anisotropic model that will be used to account for the heterogeneity of the rock. At this time, our best estimate of fracture gradient is 0.57 psi/ft. In accordance with the Wyoming Department of Environmental Quality's (WYDEQ) Water Quality Rules, Chapter 13 (020-0011-13 Wyoming Code R. **§24.18(a)**), whereby injection operations must not exceed 90% of the fracture gradient, a maximum injection pressure gradient used in the dynamic simulation model was 0.51 psi/ft.

Equation 2.2—Pressure gradient calculation.

$$P_{Constraint} = 0.9 \times FG \ \frac{psi}{ft}$$

$$P_{Constraint} = 0.9 \times 0.57 \ \frac{psi}{ft}$$

$$P_{Constraint} = 0.51 \ \frac{psi}{ft}$$

Routine core analyses are presented in Table 2.11 for the Lyons which include core plug dimensions, grain density, core porosity and water and oil saturations. Note oil saturation > 0 is indicative of oil-based mud invasion.

Table 2.11—Lyons Formation routine core analyses from Juniper M-1 (additional data to be collected from Juniper I-1 analysis). Oil saturation in cores is due to oil-based mud invasion into pore space.

| Sample ID | Top Depth (ft) | Bottom Depth (ft) | Diam (cm) | Len (cm) | Zone | Grain Den (gm/cc) | Porosity (%) | Water Sat (%) | Oil Sat (%) |
|---|---|---|---|---|---|---|---|---|---|
| 5-76 V | 9,133.2 | 9,133.6 | 3.8 | 7.4 | Lyons | 2.64 | 23.5 | 48.3 | 33.7 |
| 5-84 V | 9,141.0 | 9,141.4 | 3.8 | 7.5 | Lyons | 2.64 | 24.7 | 39.5 | 45.5 |
| 5-87 V | 9,144.7 | 9,145.1 | 3.8 | 7.9 | Lyons | 2.72 | 6.4 | 44.0 | 42.3 |
| 6-4 V | 9,150.1 | 9,150.4 | 3.8 | 7.8 | Lyons | 2.65 | 24.3 | 49.4 | 46.3 |
| 6-10 V | 9,156.6 | 9,157.0 | 3.8 | 8.0 | Lyons | 2.66 | 21.5 | 52.8 | 42.8 |
| 6-16 V | 9,162.6 | 9,163.0 | 3.8 | 8.1 | Lyons | 2.65 | 21.3 | 69.4 | 16.5 |
| 6-22 V | 9,168.0 | 9,168.4 | 3.8 | 8.0 | Lyons | 2.69 | 13.0 | 57.0 | 39.9 |
| 6-26 V | 9,172.4 | 9,172.8 | 3.8 | 7.7 | Lyons | 2.68 | 17.9 | 59.4 | 36.6 |
| 6-31 V | 9,177.6 | 9,178.0 | 3.8 | 7.6 | Lyons | 2.73 | 1.7 | 63.5 | 1.7 |

The core elastic properties were measured from two core samples from the Lyons Formation, one sample was vertically oriented and the other horizontally. The results are summarized in Table 2.12—Lyons Formation elastic properties from Juniper M-1. The measurements were recorded with a confining pressure of 34.4 MPa or 5,000 psi.

Table 2.12—Lyons Formation elastic properties from Juniper M-1 (additional data to be collected from Juniper I-1 analysis).

| | | Elastic Properties Measured at for different core orientations | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Well** | **MD** | **Orientation** | **Conf.,** | **Diff.,** | **E,** | **n** | **K,** | **G,** | **P,** |
| | **Ft.** | | **MPa** | **MPa** | **GPa** | | **GPa** | **GPa** | **GPa** |
| Juniper M-1 | 9,155.0 | Vertical | 34.4 | * | 12.0 | 0.23–0.24 | 4.1 | * | * |
| Juniper M-1 | 9,155.25 | Horizontal | 34.4 | * | 12.1 | 0.26–0.28 | 4.6 | * | * |

E = Youngs Modulus, n = Poisson's Ratio, K = Bulk Modulus, G = Shear Modulus, P = Uniaxial Strain Modulus, * Pending sampling/analysis.

#### 2.4.1.5.1 Stress

The average minimum stress for the Lyons is estimated as shown in Table 2.13.

Table 2.13—Average minimum stress of injection formation as determined by horizontal stress test (awaiting analytical results from the Spirea I-1 well).

| Depth (ft) | Average Propagation Pressure (psi) | Reopening Pressure (psi) | Closure Pressure (psi) | Average Minimum Stress (psi) |
|---|---|---|---|---|
| | | | | |

### *2.4.1.6 Geochemical Information of Injection Zone*

High Plains collected and analyzed fluid samples from the Lyons Sandstone in Juniper M-1. Water quality results reported in Table 2.14 show the Lyons Sandstone has a salinity greater than 220,000 mg/L. These data support the interpretation that the Lyons Sandstone is not a USDW at the EWS Hub. Details on the fluid sampling technique and strategy are provided in *Appendix H—Petrophysical Report*. Modeled geochemical reactions between Lyons pore fluids, host rock, and $CO_2$ using USGS PHREEQC are presented in *Section 2.4.1.8.*

High Plains plans to confirm the fluid analysis in Juniper M-1 by collecting additional samples using downhole wireline formation testing tools during the drilling of the Spirea I-1 well. This will be done to characterize the ionic composition, pH, and specific conductance of the connate waters in the injection and potential USDW zones at the injection site. These samples will be extracted from the formation in the presence of oil-based mud filtrate invasion. The downhole wireline testing tool acquisition program is designed to monitor the optical properties and resistivity of the fluids flowing into the tool until a clean water sample devoid of filtrate invasion is obtained.

In addition to fluid samples, High Plains plans to collect and analyze sidewall cores. High Plains will measure XRD mineralogy directly on the rock material, while comparing these results to those from a downhole spectroscopy tool. If a considerable change in host rock geochemistry is observed, additional geochemical modeling may be performed.

Table 2.14—Water quality of the receiving formation in Juniper M-1.

| Well Name (API) | Distance from Proposed Injection Well (miles) | Formation Name | Depth of Sample (ft) | Date of Sample Collection | Constituent | Concentration (mg/L) |
|---|---|---|---|---|---|---|
| 49-021-29548 | <1 | Lyons | 9,165–9,171 | 7/3/2023 | TDS | 226,008 |
| 49-021-29548 | <1 | Lyons | 9,165–9,171 | 7/3/2023 | TDS | 224,800 |
| 49-021-29548 | <1 | Lyons | 9,165–9,171 | 7/3/2023 | TDS | 222,935 |
| 49-021-29548 | <1 | Lyons | 9,165–9,171 | 7/3/2023 | TDS | 225,989 |

#### *2.4.1.7 Geochemical Information of Lowermost USDW*

In 2021, the USGS published a groundwater study covering southeastern Laramie County, Wyoming (Bartos et al. 2021). The study collected groundwater samples from three monitoring wells (BR-1, LN-1, and FH-1) and two production wells (FH-2 and FH-3). Figure 2.30 identifies the USGS sample wells in relation to the modeled plume extent of the proposed Spirea I-1 injection well. The results of the groundwater-quality analysis were conducted on Fox Hills (the lowermost confirmed USDW) water samples (displayed in Table 2.15), which came from the FH-1 well, located approximately eight miles southeast of the EWS Hub [11].

[11] Should any zone underlying the Fox Hills Formation be determined to meet the criteria for a USDW following further sampling, this section and table will be revised according.

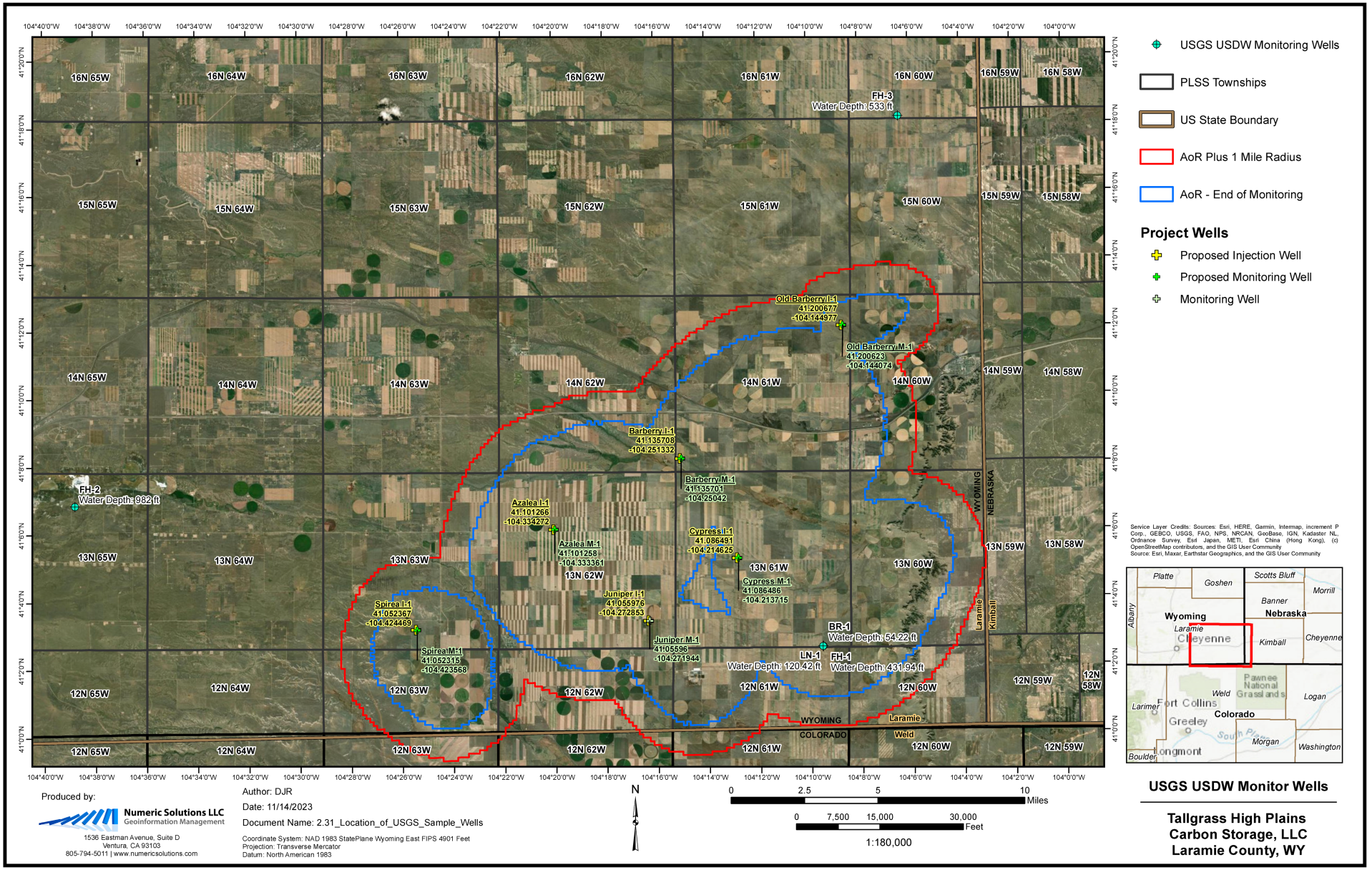


Figure 2.30—Location map of the USGS sample wells relative to the EWS Hub.

Table 2.15—Water quality of the lowermost confirmed USDW above the injection zone (Bartos et al. 2021).

| USGS Well Identifier | Formation Name | Depth of sample (ft) | Date of Sample Collection | Constituent | Concentration (mg/L, unless noted otherwise) |
|---|---|---|---|---|---|
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Temperature (°C) | 15.5 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | pH, field (standard units) | 8.9 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Specific conductance (µS/cm) | 622 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Calcium | 2.26 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Magnesium | 0.589 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Sodium | 149 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Potassium | 1.76 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Alkalinity (ppm as $CaCO_3$) | 276 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Bicarbonate | 325 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Carbonate | 6 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Chloride | 10.1 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Sulfate | 26.9 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Fluoride | 0.96 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Silica | 10.2 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | TDS (dried at 180°C) | 384 |
| FH–1 | Fox Hills | 812–832 | 11/14/2013 | Hardness (ppm as $CaCO_3$) | 8.14 |

#### *2.4.1.8 Potential Geochemical Interactions*

The following section is a summary of the geochemical modeling used to determine the compatibility of the $CO_2$ stream, pore fluids, and host mineralogy of the injection and confining zones. A detailed geochemical report, including geochemical interactions, is provided in *Appendix L—Geochemical Report*.

A geochemical analysis was performed to model potential interactions between the injected $CO_2$ stream, in-situ fluids, and minerals proximal to injection. Four models were run to evaluate independent mineral facies distributions identified within the Satanka, Lyons, Goose Egg, and Chugwater formations.

The brine composition used for the simulations is derived from water samples acquired from the Lyons Formation during the Juniper M-1 testing program. In the testing process, the well was perforated in the Lyons interval between the depths of 9,165 ft to 9,171 ft. SLB's Single-Phase Reservoir Sampler (SRS) tool was then placed at three depths while the well was pumped, resulting in samples from the target injection interval. A subset of anions and cations relevant to mineral-brine-$CO_2$ interactions are summarized for each sample in Table 2.16. The available

analytical values were averaged for each mineral facies to create a composite brine composition that was used in each model (Table 2.17).

Table 2.16—Composition of Lyons water samples.

| Formation | Depth | pH | TDS | $HCO_3$ | $SO_4$ | Cl | I | Ca | Fe | K | Mg | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lyons | 9,081.92 | 6.36 | 216,280 | 134 | 3,515 | 128,666 | 126 | 495 | 18 | 2,529 | 904 | 82,175 |
| Lyons | 9,096.26 | 6.43 | 216,280 | 160 | 3,610 | 128,581 | 0 | 508 | 18 | 2,426 | 874 | 80,734 |
| Lyons | 9,066.67 | 6.45 | 216,280 | 130 | 3,607 | 128,976 | 127 | 500 | 18 | 2,564 | 948 | 79,384 |

Table 2.17—Average brine composition by mineral facies.

| Mineral Facies | Facies Name | Modeled Depth | Strat Interval | pH | TDS | $HCO_3$ | $SO_4$ | Cl | I | Ca | Fe | K | Mg | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Facies 0 | Sandstone | 9,153 | Lyons | 6.40 | 216,280 | 147 | 3,577 | 128,741 | 84 | 501 | 18 | 2,506 | 909 | 80,764 |
| Facies 1 | Mudstone | 8,727 | Chugwater | 6.40 | 216,280 | 147 | 3,577 | 128,741 | 84 | 501 | 18 | 2,506 | 909 | 80,764 |
| Facies 1 | Mudstone | 9,187 | Satanka | 6.40 | 216,280 | 147 | 3,577 | 128,741 | 84 | 501 | 18 | 2,506 | 909 | 80,764 |
| Facies 2 | Carbonate and Dolostone | 9,119 | Goose Egg | 6.40 | 216,280 | 147 | 3,577 | 128,741 | 84 | 501 | 18 | 2,506 | 909 | 80,764 |

Data from 24 core plug samples obtained during the Juniper M-1 testing program, across the injection and seal intervals, were used in this analysis. Those samples were used in conjunction with XRF data to calibrate the multi-mineral model for the Juniper M-1 well and to create an LAS file. Average mineralogic compositions were calculated for each of the four mineral facies and used to represent the injection and seal zone mineralogy for batch modeling. Mineral compositions used in the models are shown in Table 2.18.

Table 2.18—Mineral composition of facies clusters.

| Mineral Facies | Facies Name | Modeled Depth | Stratigraphic Interval | Quartz | Calcite | Plag (albite) | K-spar | Smectite | Illite | Anhydrite |
|---|---|---|---|---|---|---|---|---|---|---|
| Facies 0 | Sandstone | 9,153 | Lyons | 76.6 | 0 | 4 | 6.3 | 0 | 1.9 | 9.6 |
| Facies 1 | Mudstone | 8,727 | Chugwater | 34 | 30 | 0 | 0 | 3.2 | 28.8 | 0 |
| Facies 1 | Mudstone | 9,187 | Satanka | 42 | 25 | 0 | 0 | 2.7 | 24.3 | 0 |
| Facies 2 | Carbonate | 9,119 | Goose Egg | 13 | 46 | 0 | 0 | 1.2 | 10.8 | 27 |

The Chugwater and Lyons formation models were evaluated at their average depth. The Goose Egg model was evaluated at the Goose Egg-Lyons interface. The Satanka model was evaluated at the Lyons-Satanka interface. Across all the models, the simulations show a net mineral change of

less than 8%. Reactions begin to occur after a few seconds of contact and accelerate through the first several hundred years. From 1,000 to 10,000 years the reactions reach equilibrium.

In the Lyons injection interval, the largest constituent (quartz) shows net precipitation while in the minor constituents anhydrite, k-feldspar, plagioclase (albite), and illite dissolve while kaolinite and calcite precipitate. Mild net precipitation in the injection facies will lead to a small amount of porosity reduction over time especially at the upper confining zone-injection zone interface. Geochemical modeling indicates the net precipitation and alteration of illite to smectite at the Goose Egg-Lyons interface supports seal capacity over the course of injection. Please refer to the Geochemical and Petrophysical Reports provided in the "Additional Reports" attachment folder for additional reference material.

The casing that will be exposed to the injection zone was selected to resist the potential corrosion caused by exposure to carbonic acid created by the interaction between $CO_2$, $O_2$, and brine in the injection formation. The use of $CO_2$ resistant casing will be sufficient to withstand the corrosive effects on the casing.

To determine the mineralogical composition of the Lyons Formation, XRD elemental analysis was performed on the core collected in the Juniper M-1 characterization well (Table 2.19). Formation water chemistry is provided in Table 2.20.

Table 2.19—Average geochemical data (XRD) from 28 samples of the Lyons Formation from the Juniper M-1 well. Volume may not sum to 100 due to round off errors.

| Mineral(s) | Average Value (Volume Percent) |
|---|---|
| Quartz | 64.7 |
| Plagioclase | 3.4 |
| Feldspar | 5.6 |
| Calcite | 0.0 |
| Dolomite | 0.0 |
| Magnesite | 0.6 |
| Hematite | 0.0 |
| Siderite | 0.0 |
| Apatite | 0.0 |
| Gypsum | 0.1 |
| Anhydrite | 7.8 |
| Pyrite | 0.0 |
| Chlorite | 0.0 |
| Kaolinite | 0.0 |
| Illite & Mica | 1.6 |
| MXL I/L | 0.0 |
| Corrensite | 0.5 |
| Phi total | 15.7 |
| Total | 100 |
| Sample Depth (ft) | averages from 9,127.7 to 9,185.7* |

Four water samples were collected from the Lyons Formation between the perforated depths of 9,165–9,171 ft in the Juniper M-1 well. Analysis of the four samples were averaged and are provided in Table 2.20.

Table 2.20—Formation water chemistry from the injection formation.

| Parameter | Results (mg/L) |
|---|---|
| Alkalinity, as Bicarbonate ($HCO_3^-$) | 140.8 |
| Alkalinity, as Carbonate ($CO_3^{2-}$) | 0.0 |
| Alkalinity, as Hydroxide ($OH^-$) | 0.0 |
| Boron | 47.7 |
| Barium | <0.1 |
| Bromide | 48.9 |
| Calcium | 498.3 |
| Chloride | 128,679.6 |
| Dissolved Inorganic Carbon (DIC) | Not analyzed |
| Dissolved Organic Carbon (DOC) | 1.09 |
| Iron | 17.9 |
| Lead | 0.1 |
| Lithium | 13.9 |
| Magnesium | 893.4 |
| Potassium | 2,528.6 |
| Sodium | 80,832.7 |
| Sulfate | 3,585.6 |
| Strontium | 12.7 |
| TDS | 224,910.3 |
| Zinc | 4.0 |

The expected $CO_2$ stream composition at the EWS Hub is provided in Table 2.21.

Table 2.21—Expected $CO_2$ stream composition that will be injected into the Lyons Formation.

| Component | ppm | Mol% |
|---|---|---|
| Carbon Dioxide ($CO_2$) | | $\geq$ 95 |
| Oxygen ($O_2$) | | $\leq$ 1 |
| Nitrogen Oxides ($NO_x$) | $\leq$ 10 | |
| Total Hydrocarbons (as $CH_4$) (Maximum cricondentherm dew point of hydrocarbon mix -20°F.) | | $\leq$ 4 |
| Total Sulfur (S) | $\leq$ 35 | |
| Water ($H_2O$) | $\leq$ 150 | |
| Carbon Monoxide (CO) | | $\leq$ 0.4 |

### *2.4.2 Confining Zones*

The Satanka and composite Goose Egg and Chugwater Formations represent the lower and upper confining zones, respectively. These intervals contain high concentrations of shale, silt, salt, or anhydrite in the section, each known for their sealing characteristics and represent the proposed confinement intervals of the Lyons injection complex. Table 2.22 depicts the confining intervals relative to an offset open-hole log. The properties of the gross upper and lower confining zones are provided in Table 2.22. Porosity and permeability values displayed represent petrophysical

averages from the Juniper M-1 well (API# 49-021-29548), located within the AoR of the proposed injection well.

Table 2.22—Properties of the injection and upper and lower confining zones. Based on Juniper M-1 log and core data.

| Confining Zone Properties | Injection Zone | Upper Confining Zone | Upper Confining Zone | Lower Confining Zone |
|---|---|---|---|---|
| Formation Name | Lyons | Chugwater | Goose Egg | Satanka |
| Lithology | Eolian sandstone | Interbedded silt and red shale | Interbedded anhydrite and shale | Interbedded silt and red shale |
| Formation Top Depth (ft, MD) | 9,128 | 8,631 | 8,880 | 9,194 |
| Gross Thickness (ft) | 66.7 | 249 | 248 | 189 |
| Net Thickness >10% PHIT (ft) | 54.3 | 0 | 0 | 0 |
| Net to gross ratio | 54.3/66.7 | 0 | 0 | 0 |
| Total Porosity (%, avg. from logs*) | 17.6** | 5 | 4 | 5 |
| Effective Porosity (%, avg. from logs*) | 16.8** | 0 | 1 | 0 |
| Permeability (mD, average from logs*) | 337** | 0.01 | 0.01 | 0.01 |
| Capillary Entry Pressure (Gas-Water) (psi) | 3 | 8,287*** | 6,101*** | 3,560*** |
| Depth below base of the lowest confirmed USDW (ft) | 7,906 | 7,408 | 7,642 | 7,972 |

*From petrophysical models correlated to core data.
**Calculated for net reservoir quality rock >10% porosity [net to gross ratio 54.3/66.7].
***Only core samples containing seal quality rock were averaged.

### *2.4.2.1 Upper Confining Composite*

Upper confinement of the Lyons injection interval is provided by a >500 ft-thick, regionally extensive composite of the overlying Goose Egg and Chugwater Formations, as depicted in Figure 2.18. The Goose Egg Formation is present across the eastern half of Wyoming and is equivalent to the Lykins Formation of eastern Colorado (Figure 2.31). The geologic section contains an interbedded sequence of shales, siltstones, limestones, and evaporites that are red to ocher in color and Permian to Lower Triassic in age. The group derived its name from an outcrop in Central Wyoming, near the Goose Egg Post Office, where the strata were first named and described, approximately 160 miles northwest of the EWS Hub (Burk and Thomas 1956). Figure 2.32 contains a generalized lithologic description of the Goose Egg and Chugwater Formations at the

type locality. The descriptions are representative of anticipated lithologies within the upper confining interval of the EWS Hub. Sections described as gypsum are expected to be anhydrite or halite in the subsurface due to compaction and dewatering that tend to occur along with burial.

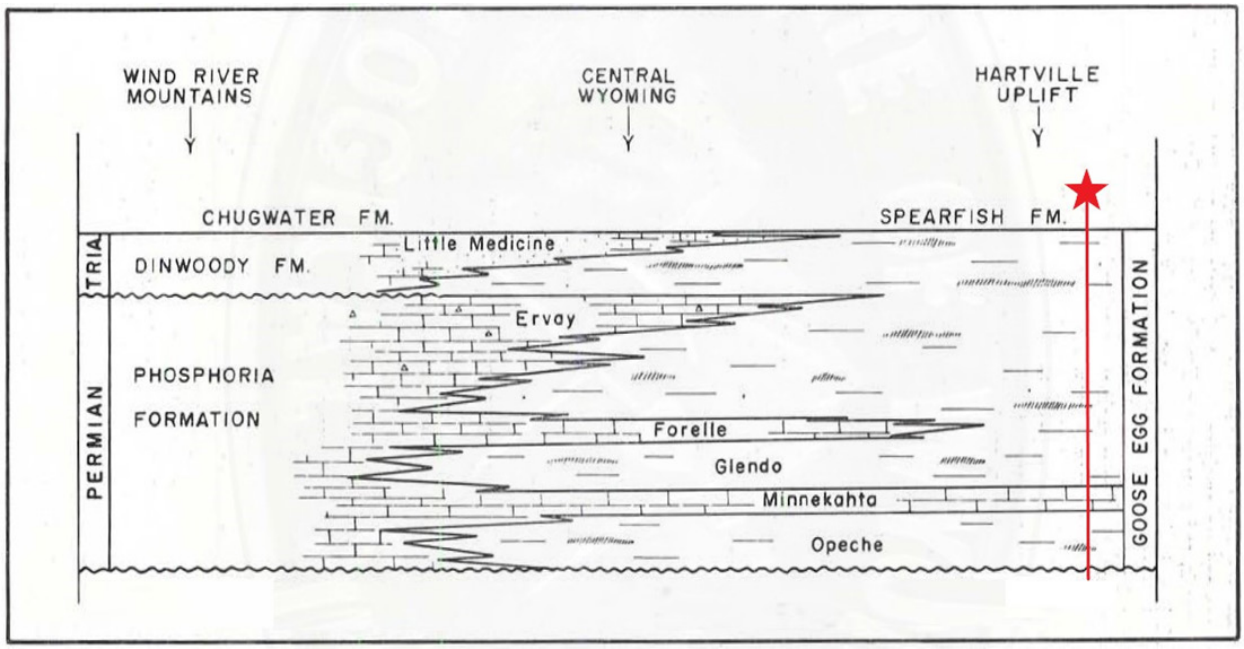


Figure 2.31—Schematic cross section depicting the stratigraphic relationship of Goose Egg Formation with the time-equivalent Phosphoria and Dinwoody formations from the Wind River Mountains to the Hartville Uplift, Wyoming (Burk and Thomas 1956). The red star and line represent the approximate location of the EWS Hub.

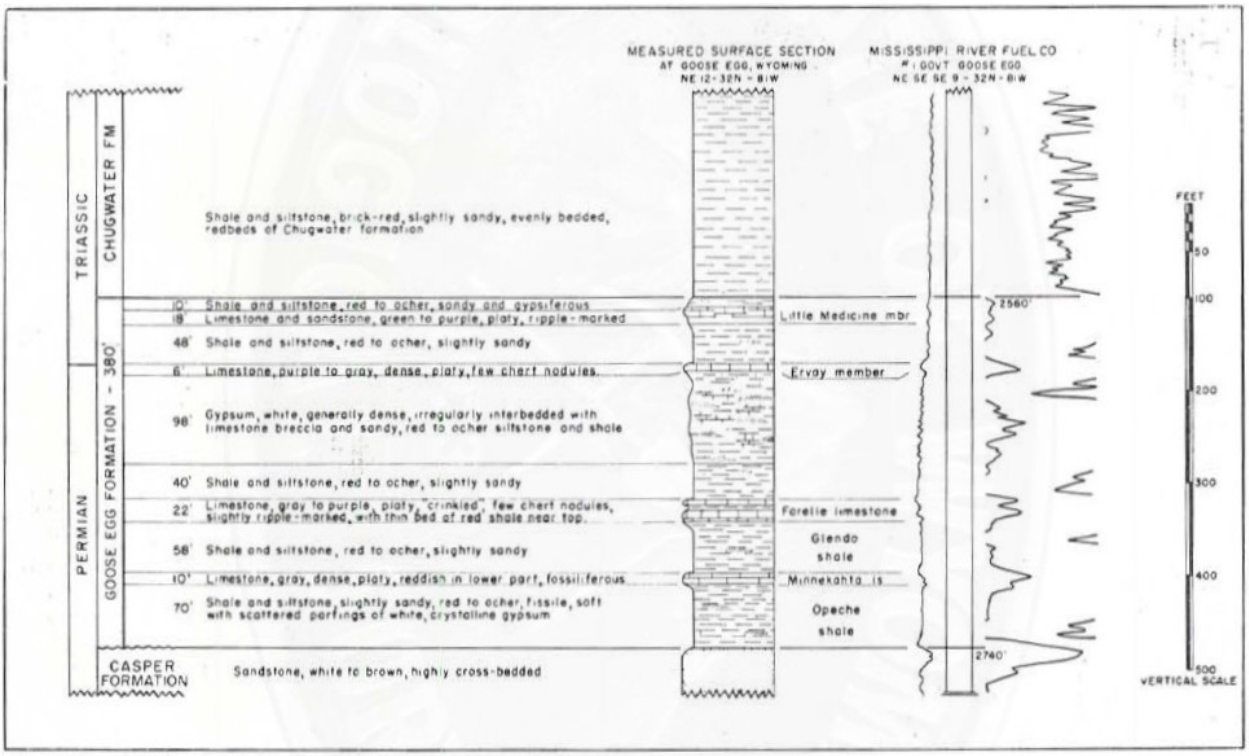


Figure 2.32—Generalized lithology of the Goose Egg and Chugwater at type location (NW1/4, Sec.12, T.32N, R.81W) with electric log character of formation in nearby subsurface (Burk and Thomas 1956).

A disconformity at the base of the Goose Egg was described by Burk and Thomas (1956), but more recent investigations (Oldham 1996) suggest, and High Plains' interpretation supports, that continual deposition through a sea level transgression occurred where an aeolian environment was drowned to form a sabkha/tidal flat environment. This transgression resulted in a sharp contact between the Lyons Sandstone and overlying Goose Egg anhydrite with anhydrite cement percolating down into the Lyons Sandstone, as described in the Juniper M-1 core. The nature of such a disconformity, if present, is such that no additional facies would occur underlying the Goose Egg Formation in the AoR. Therefore, the effectiveness of the upper confining zone is unaffected by the presence, or absence, of such a disconformity.

The Goose Egg overlies the Lyons injection interval and is anticipated to be encountered at approximately -3,743 ft SSTVD in the Spirea I-1 well, with a gross thickness of approximately 300 ft. The schematic cross section displayed in Figure 2.33 illustrates the stratigraphic relationships of Goose Egg members and clarifies nomenclature changes among regions. The Forelle and Minnekahta limestone tongues are anticipated to be encountered at the EWS Hub location. Carbonate beds of the Goose Egg consist primarily of fine crystalline dolomite to dolomitic limestones with some fine crystalline limestone. These carbonate tongues are distributed within a sequence of red beds and evaporites. The red sediments of the Goose Egg consist of nonresistant shales, mudstones, and siltstones that generally lack any prominent structure. Typical detrital constituents of the red sediments are quartz and feldspar with some mudstone, shale fragments, mica, carbonate grains, and magnetite-ilmenite-leucoxene. Beds are poorly developed and grade vertically and laterally into the evaporites of the Goose Egg depositional sequence (Campbell 1963). All the facies contained within the Goose Egg are characterized by very low porosity and permeability (Table 2.22) that should restrict migration of fluid and cause the formation to act as a confining interval. Review of regional literature and site characterization of the thick, regionally extensive geologic sequence suggest the Goose Egg is well-suited to act as the upward confining layer to the injection complex.

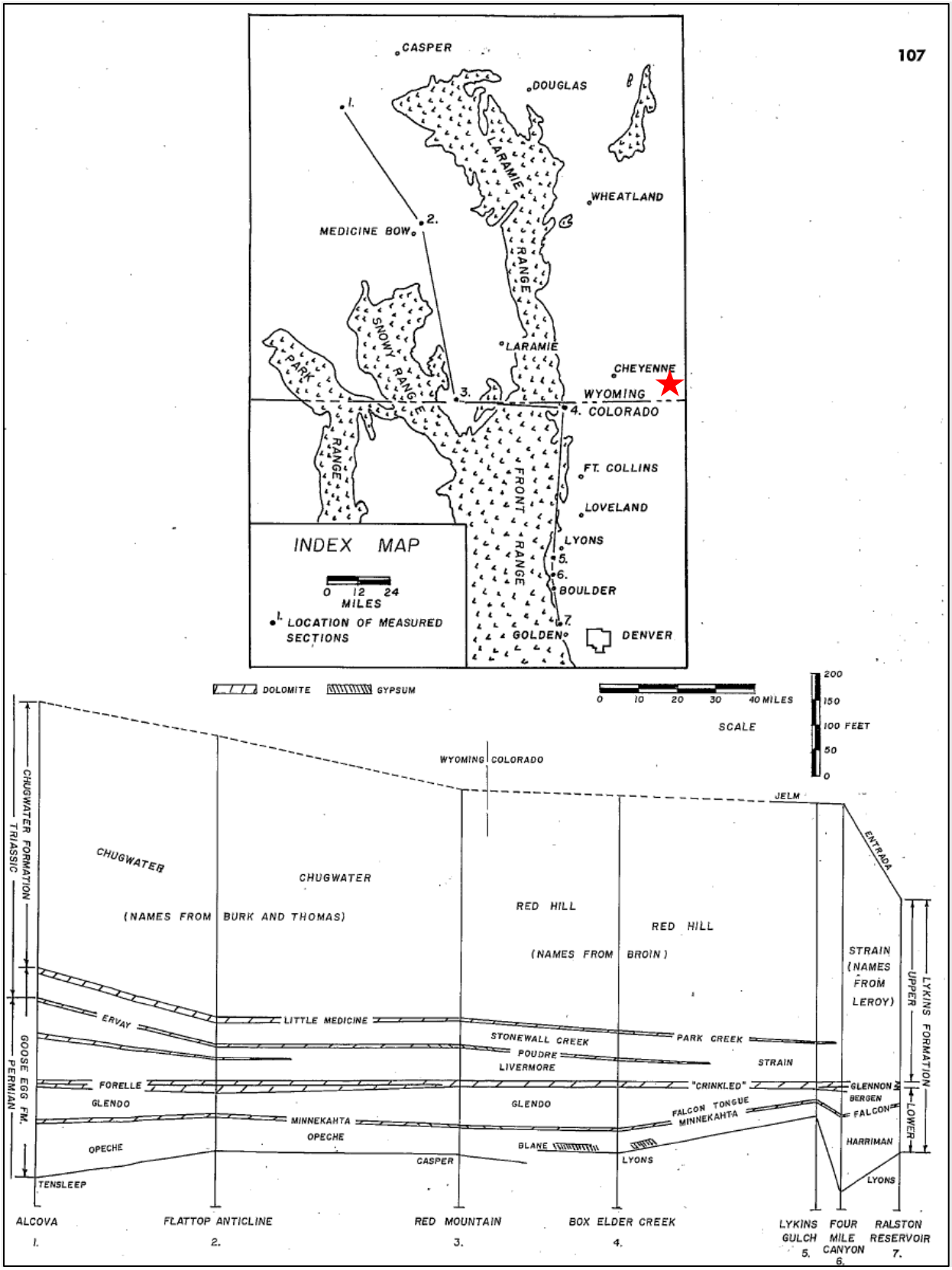


Figure 2.33—Schematic cross section illustrating relationship of Goose Egg Formation to Lykins Formation, from Central Wyoming to Golden, Colorado (Campbell 1963).

The Chugwater conformably overlies the Goose Egg Group and will provide additional geologic confinement to the proposed storage complex. According to the description provided in Figure 2.32 by Burk and Thomas (1956), the Chugwater Formation consists of brick-red shale and siltstone that is slightly sandy and evenly bedded. This description agrees with other published Chugwater descriptions for the region and is representative of anticipated lithology at the EWS Hub location. Shales and siltstones of the Chugwater Formation share sediment sources of the underlying Goose Egg Formation but with less carbonate influx and can generally be differentiated by their lighter ocher color. Facies within the Chugwater Formation are anticipated to contain less lateral variability than the Goose Egg, which is likely attributed to a decrease in evaporate content and a more stable depositional environment associated with the deposition of thick regional shales and siltstones. Beds of the Chugwater Formation are less resistive than the Goose Egg Formation, resulting in higher resistivities on electric logs (Burk and Thomas 1956; Campbell 1963). This allows for easy differentiation of the upper confining units on open-hole logs.

Regional mapping performed by High Plains indicates that Spirea I-1 will encounter the top of the Chugwater Formation at approximately -3,464 ft SSTVD with a gross thickness of approximately 230 ft. A structure map generated on the top of the Chugwater with offset well logs and formation picks is displayed in Figure 2.34 to demonstrate the structural behavior of the area. Internal 2D seismic interpretations located near the EWS Hub were also incorporated to improve structural detail of the resulting map. The structure strikes north-south and has a gentle dip to the west, with a surface variation of approximately 1,800 ft within the map extents.

Offset open-hole logs were also utilized to construct a gross isopach map of the upper confining composite (Figure 2.35). The map suggests the upper confining composite interval will be approximately 540 ft thick at the EWS Hub location. The gross thickness ranges from 350 ft to 650 ft but is greater than 475 ft throughout modeled plume extents of Spirea I-1. Local cross sections (Figure 2.27 and Figure 2.28) and the accompanying locator maps demonstrate a consistent structural interpretation, with a thick regionally extensive upper confining complex that is present—well beyond the limits of the EWS Hub.

Core was cut in the Goose Egg Group and Chugwater formations during the drilling of Juniper M-1. Measurements made of the core support the previously developed petrophysical model. The proposed Goose Egg upper confining interval has an average total porosity of 4%, an effective porosity of ±1% and an average gross permeability of 0.01 mD (Table 2.22). The proposed Chugwater upper confining interval has an average total porosity of 5%, an effective porosity of near zero, and an average air permeability of 0.001 mD (Table 2.22). Figure 2.36 displays a map of the average gross porosity of the Chugwater through Goose Egg formations. Porosity is generally low and does not exhibit much variation within the map extents.

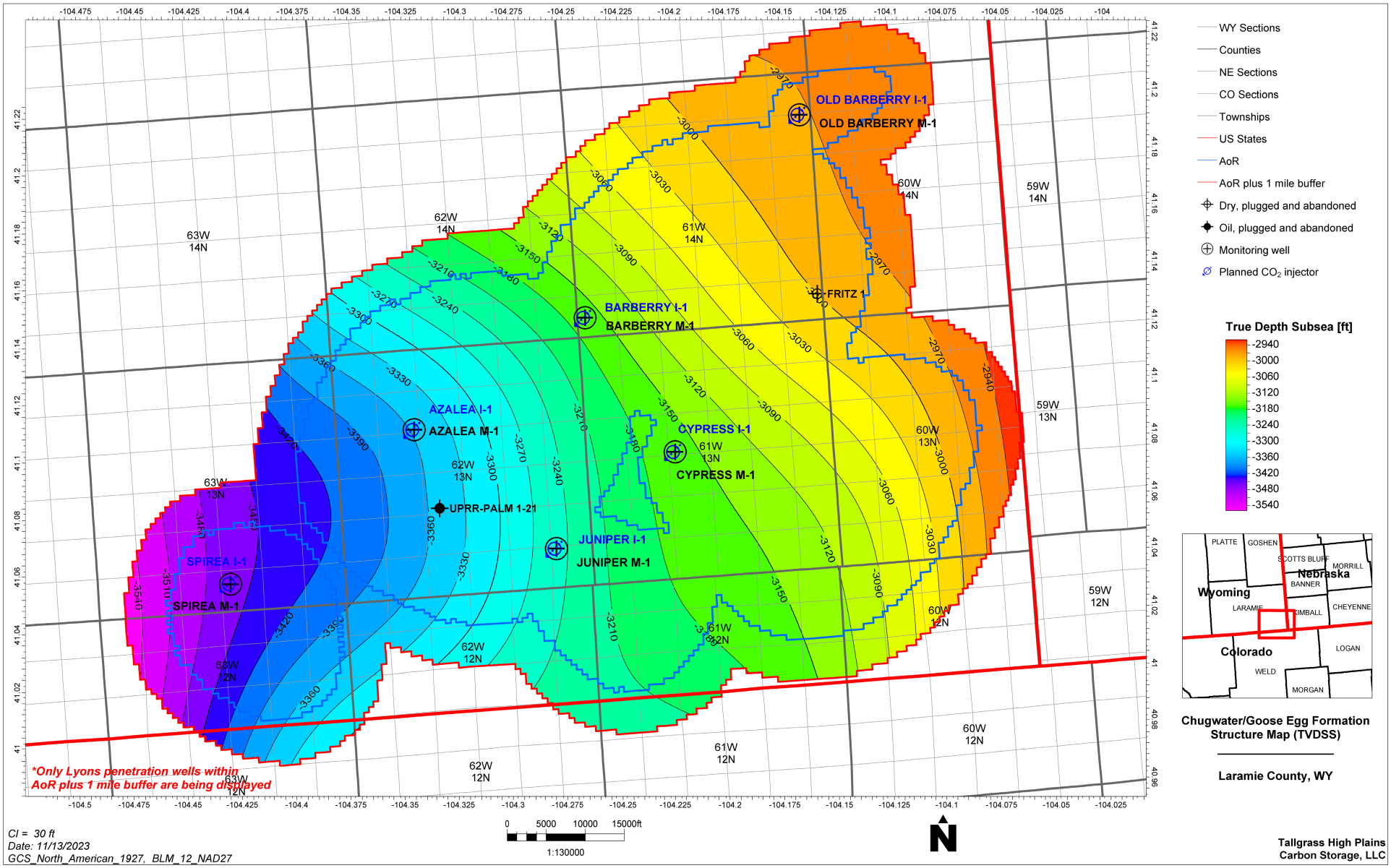


Figure 2.34—Subsea structure map of the upper confining zone, the Chugwater Formation.

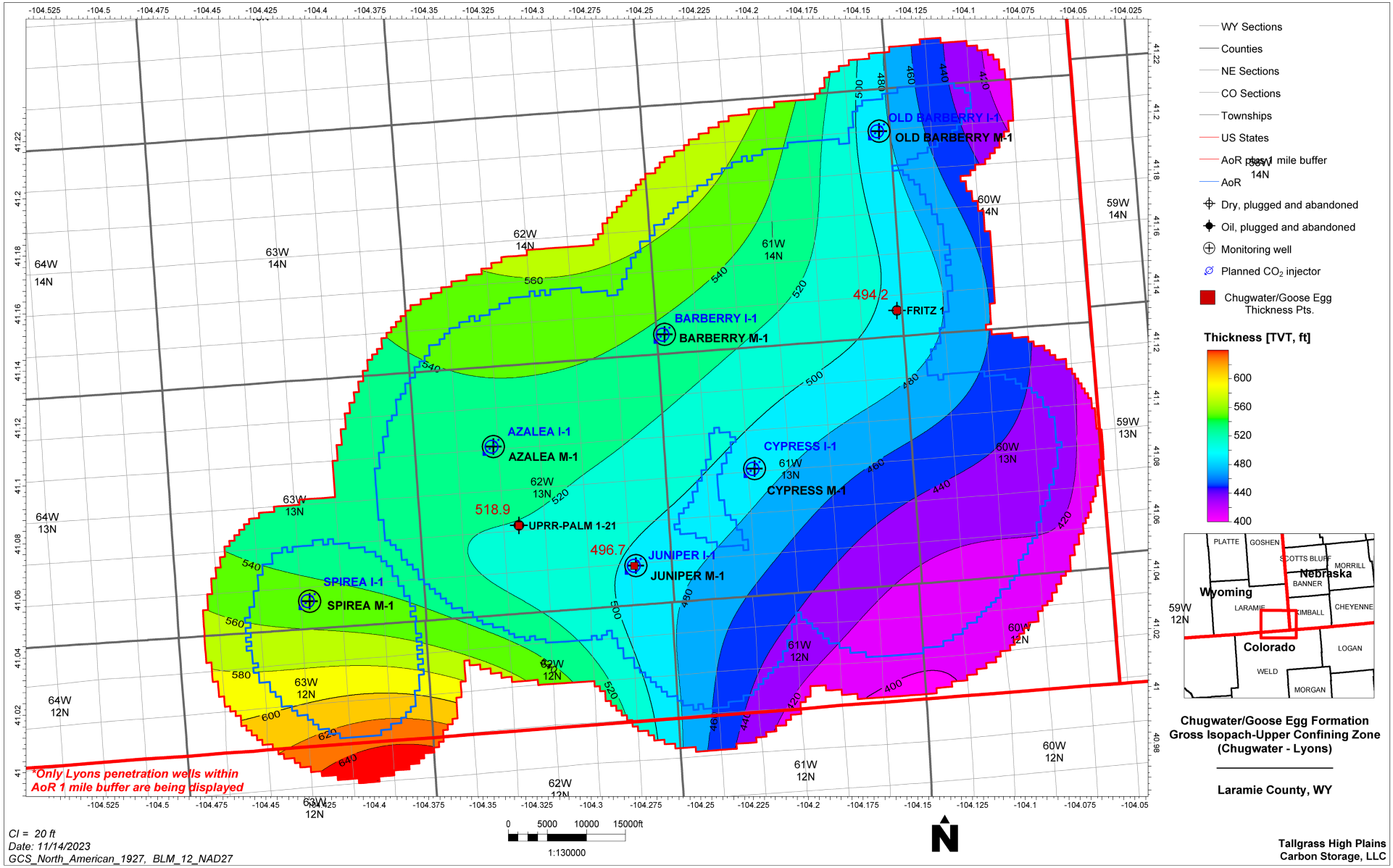


Figure 2.35—Gross isopach map of the upper confining zones, the Chugwater and Goose Egg Formations.

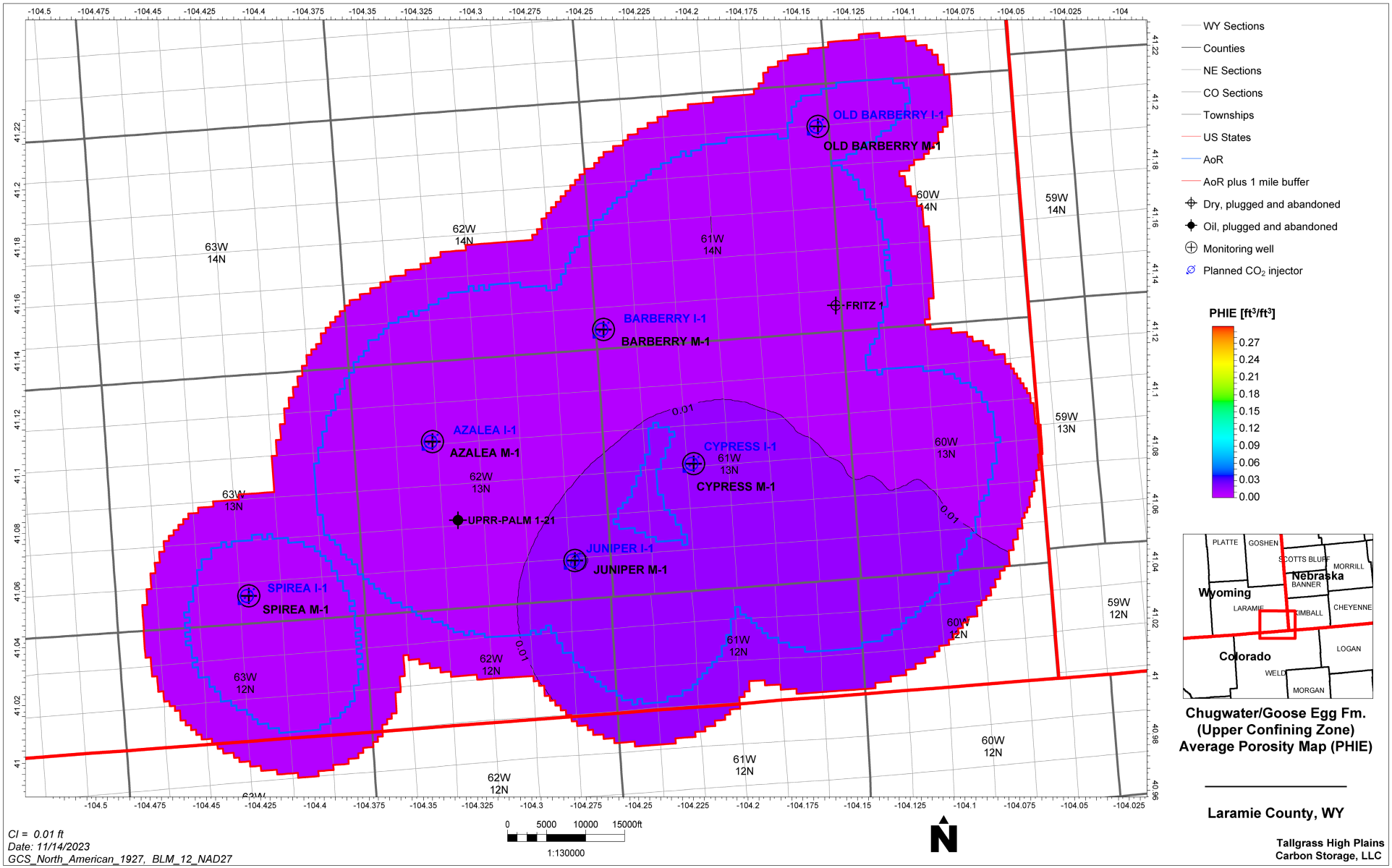


Figure 2.36—Average porosity of the upper confining zone, the Chugwater and Goose Egg Formations.

#### 2.4.2.1.1 Mineralogy

The mineralogy for the Goose Egg and Chugwater upper confining intervals were determined from the conventional core analysis in the Juniper M-1 characterization well. These values are presented in Table 2.23.

Table 2.23—Upper confining zone XRD mineralogy results from Juniper M-1. Totals may not equal 100 percent due to round off error.

| Mineral(s) | Goose Egg Average Value (Volume Percent) | Chugwater Average Value (Volume Percent) |
|---|---|---|
| Quartz | 21.6 | 34.9 |
| Plagioclase | 4.8 | 9.1 |
| K-Feldspar | 5.3 | 5.9 |
| Calcite | 0.0 | 0.0 |
| Dolomite | 16.4 | 10.9 |
| Magnesite | 0.0 | 0.0 |
| Hematite | 0.3 | 0.8 |
| Siderite | 0.0 | 0.0 |
| Apatite | 0.0 | 0.0 |
| Gypsum | 0.0 | 0.0 |
| Anhydrite | 24.2 | 3.8 |
| Pyrite | 0.0 | 0.0 |
| Chlorite | 1.1 | 2.6 |
| Kaolinite | 0.0 | 0.0 |
| Illite & Mica | 6.2 | 21.0 |
| MXL I/L | 0.1 | 2.3 |
| Corrensite | 15.3 | 4.1 |
| Phi total | 4.5 | 4.4 |
| Total | 100 | 100 |
| Sample Depth (ft)* | averages from 8,917.6 to 9,058.8 | averages from 8,667.9 to 8,850.0 |

*Depths reported include a depth shift of +10.5 ft.

#### 2.4.2.1.2 Geochemical Interaction

A discussion on potential geochemical interactions between the $CO_2$ stream, pore fluids, and host mineralogy of the injection and confining zones is provided in Section 2.4.1.8. A detailed geochemical report, including geochemical interactions, is also provided in the Appendix L—Geochemical Report.

#### 2.4.2.1.3 Geomechanical Information

An industry standard methodology was used to determine fracture gradient of a given rock. For this method, an isotropic model was used based on the dipole sonic log recorded in Juniper M-1. Further data will be recorded in Juniper I-1 to confirm interpretation from Juniper M-1. Once additional data has been gathered, updated inputs will be incorporated into an anisotropic model that will be used to account for the heterogeneity of the rock. At this time, our best estimate of fracture gradient is 0.61 psi/ft.

The core elastic properties were measured from eight core samples from the upper confining zones. Four samples were vertically oriented and the other four horizontally oriented. The results are summarized in Table 2.22. The measurements were recorded with a confining pressure of 51.7 MPa or 7,500 psi.

Routine core analyses are presented in Table 2.24 for the Goose Egg Formation which include core plug dimensions, grain density, core porosity and water and oil saturations. Oil Saturations greater than zero indicate invasion of oil-based mud (OBM) into the pore space. Geomechanical properties of the upper confining zone are presented in Table 2.25.

Table 2.24—Upper confining zone routine core analyses properties.

| Sample ID | Top Depth (ft) | Bottom Depth (ft) | Diam. (cm) | Len. (cm) | Zone | Grain Den. (gm/cc) | Porosity (%) | Water Sat. (%) | Oil Sat. (%) |
|---|---|---|---|---|---|---|---|---|---|
| 5-58 V | 9,115.60 | 9,115.98 | 3.84 | 7.37 | Goose Egg | 2.72 | 4.3 | 47.3 | 26.1 |
| 5-62 V | 9,119.00 | 9,119.31 | 3.83 | 4.41 | Goose Egg | 2.71 | 7.6 | 38.1 | 36.1 |
| 5-66 V | 9,123.30 | 9,123.68 | 3.85 | 6.84 | Goose Egg | 2.73 | 2.9 | 57.3 | 24.7 |
| 5-72 V | 9,129.00 | 9,129.34 | 3.82 | 7.73 | Goose Egg | 2.71 | 6.6 | 50.6 | 38.6 |

Table 2.25—Goose Egg and Chugwater elastic properties from Juniper M-1 (additional data to be collected from Juniper I-1 analysis).

| Well | MD (ft) | Orientation | Elastic Properties Measured in different orientations. Conf. (MPa) | Diff. (MPa) | E (GPa) | n | K (GPa) | G, (GPa) | P (GPa) |
|---|---|---|---|---|---|---|---|---|---|
| Juniper M-1 | 8,874.45 | Vertical | 51.7 | * | | | | * | * |
| Juniper M-1 | 8,874.35 | Horizontal | 51.7 | * | 46.7 | 0.23-0.25 | 28.27 | * | * |
| Juniper M-1 | 9,029.45 | Vertical | 51.7 | * | | | | * | * |
| Juniper M-1 | 9,030.13 | Horizontal | 51.7 | * | 50.1 | 0.24-0.28 | 16.6 | * | * |
| Juniper M-1 | 9,070.54 | Vertical | 51.7 | * | 48.3 | 0.22-0.23 | 27.7 | * | * |
| Juniper M-1 | 9,070.23 | Horizontal | 51.7 | * | 55.1 | 0.24-0.27 | 29.9 | * | * |
| Juniper M-1 | 9,110.40 | Vertical | 51.7 | * | 25.6 | 0.20-0.25 | 13.9 | * | * |
| Juniper M-1 | 9,110.40 | Horizontal | 51.7 | * | 33.4 | 0.24-0.30 | 12.8 | * | * |

E = Youngs Modulus, n = Poisson's Ratio, K = Bulk Modulus, G = Shear Modulus, P = Uniaxial Strain Modulus, * Pending sampling/analysis.

#### 2.4.2.1.4 Confining Zone Integrity

Immediate upper confinement of the Lyons injection interval is provided by over 300 ft of tight Goose Egg Formation that is composed of a sequence of shale and siltstone interbedded with limestone, anhydrite, halite, and gypsum. The petrophysical analysis used to model the EWS Hub indicates the Goose Egg contains an average total porosity of <5% and an average permeability of 0.01 mD (Table 2.22). The stark contrast of observed porosity and permeability between the injection interval and overlying confinement indicates the stratigraphic boundary contains the physical properties required to reduce the vertical transmission of fluids and constrain $CO_2$ from migrating out of the injection reservoir. The Goose Egg Formation is immediately overlain by the upper confining Chugwater Formation. The formation contains over 200 ft of additional brick red shale and siltstone that is slightly sandy and evenly bedded. Petrophysical analysis of the Chugwater Formation determined an average total porosity of <5% and an average permeability of 0.01 mD (Table 2.22).

The composite Goose Egg and Chugwater formations total approximately 500 ft thick and contain high concentrations of shale, silt, salt, or anhydrite in the section. These lithologies are known for their sealing characteristics and represent the proposed upper confinement interval of the Lyons injection complex. Proposed confining intervals are thick, tight, and continuous across the EWS Hub, and contain physical properties necessary to restrict the migration of $CO_2$ and other formation fluids. The 2D seismic evaluation referenced in *Section 2.3.7* did not identify any faults within the AoR of the proposed Spirea I-1 injection well.

#### 2.4.2.1.5 Additional Overlying Confining Zones

The DJ Basin was subject to deposition of several thousand feet of Cretaceous shale, sandy shale, and carbonate over Triassic sediments. These shales and tight carbonate formations have been identified by the WSGS as impermeable confining formations that will provide additional protection between the injection interval and lowermost confirmed USDW. Figure 2.2 depicts primary and secondary zones of confinement relative to the stratigraphic column. Table 2.26 provides a brief description of additional confining zones with approximate formation tops for the Spirea I-1 well location.

Table 2.26—Description of zones of confinement above immediate upper confining zone.

| Name of Formation | Lithology | Formation Top Depth (ft) | Thickness (ft) | Depth Below Base Lowest Confirmed USDW (ft) |
|---|---|---|---|---|
| Pierre | shale | 1,369 | 5,881 | 0 |
| Niobrara/Carlile | calcareous shale | 7,250 | 508 | 5,881 |
| Greenhorn | shale | 7,758 | 43 | 6,389 |
| Graneros/Belle Fourche | shale | 7,801 | 325 | 6,432 |
| Mowry/Huntsman | siliceous shale | 8,126 | 169 | 6,757 |
| Skull Creek/Thermopolis | shale | 8,375 | 249 | 7,006 |

### *2.4.2.2 Lower Confining Zone*

Lower confinement of the Lyons Formation is provided by the underlying Satanka Formation. The literature shows regional variation in the nomenclature of the Satanka. For the purposes of this application, the term Satanka is applied to the sequence of red shales and siltstones underlying the Lyons Sandstone around the EWS Hub site. The Satanka unconformably overlies the Wolfcamp Formation and is anticipated to be encountered at approximately -4,075 ft SSTVD in the Spirea I-1 well with a gross thickness of approximately 200 ft.

The lithology of the Satanka Formation is anticipated to consist of shale and siltstone with the potential for minor evaporite interbeds. The Satanka contains regular bedding and lacks cut and fill structures, suggesting the shale and silt sediments were deposited in a stable marine environment. The deep red to maroon color of the Satanka has been hypothesized by Hoyt (1963) to have developed due to abnormally high marine water salinity present during deposition. Marine water with abnormally high salinity can increase organism scarcity, which reduces the influence of decaying organic matter and increases the preservation of hematite. A general lack of fossils in the Satanka record and the presence of evaporites in overlying stratigraphic section support the presence of highly saline marine waters during deposition of the Satanka (Hoyt 1963). Evaporites are recorded within the Satanka Formation but are not anticipated to be present within the Satanka at the Spirea I-1 location.

Thomas (1934) originally proposed that the Satanka represented a lower tongue of the Chugwater and Goose Egg group of Wyoming. Apparent shared lithology and mineralogic constituents of the Satanka and Chugwater formations add some credence to this interpretation. However, Hoyt (1963) identified the Opeche Shale member of the Goose Egg group as a well-defined geologic unit that can be distinguished by lower sand and silt content and higher resistivity on electric logs. Modern open-hole logs and resulting petrophysical analysis demonstrate the Satanka Formation contains the highest quartz concentrations/sand constituents of the confining intervals (see Section 2.4.2.2.1—Mineralogy) and exhibits the lowest resistivity among confining intervals. These petrophysical properties agree with Hoyt (1963) and suggest his work further refined the characterization of Permian-Pennsylvanian unconformities in the region. Although Satanka quartz content is relatively high when compared to the other confining intervals at the EWS Hub location, the quartz content is low relative to regional Satanka mineralogy trends. Sand content within the Satanka Formation tends to increase moving south, getting progressively sandier, with the eventual development of sandstone facies south of the EWS Hub between Dry Creek and Lyons, Colorado. The sand body does not cover enough areal extent to establish a new formation name and is referred to as "the sandstone facies of the Satanka Formation" (Hoyt 1963).

Regional mapping performed by High Plains indicates that Spirea I-1 will, as noted above, encounter the top of Chugwater at approximately -3,464 ft SSTVD with a gross thickness of approximately 230 ft (Table 2.22). A structure map generated on the top of the Satanka Formation with offset well logs and formation picks is displayed in Figure 2.37 to demonstrate the structural behavior of the formation at the EWS Hub site. The map also honors interpretations of several local 2D seismic lines to improve the map's structural detail. The structure strikes north-south and has a gentle dip to the west, with relief of approximately 1,900 ft within the map extents. Open-hole logs were also utilized to construct a gross isopach of the lower confining interval (Figure 2.38). The mapped gross thickness of the Satanka ranges from 165 ft to 265 ft within the mapped extents of the EWS Hub site. Local cross sections (Figure 2.27 and Figure 2.28) and the accompanying locator map demonstrate the consistent structural setting near the EWS Hub site, with a thick regionally extensive lower confining interval present well beyond the limits of the modeled plume migration.

Core was collected across the Satanka Formation in the Juniper M-1 characterization well. The analysis of the core suggests the proposed Satanka lower confining interval has an average total porosity of <5%, with an effective porosity near 0% and a permeability of 0.01 md (Table 2.22). A map of the average porosity of the Satanka lower confining interval is displayed in Figure 2.39. Porosity is generally low and exhibits minor variation within the map extents.

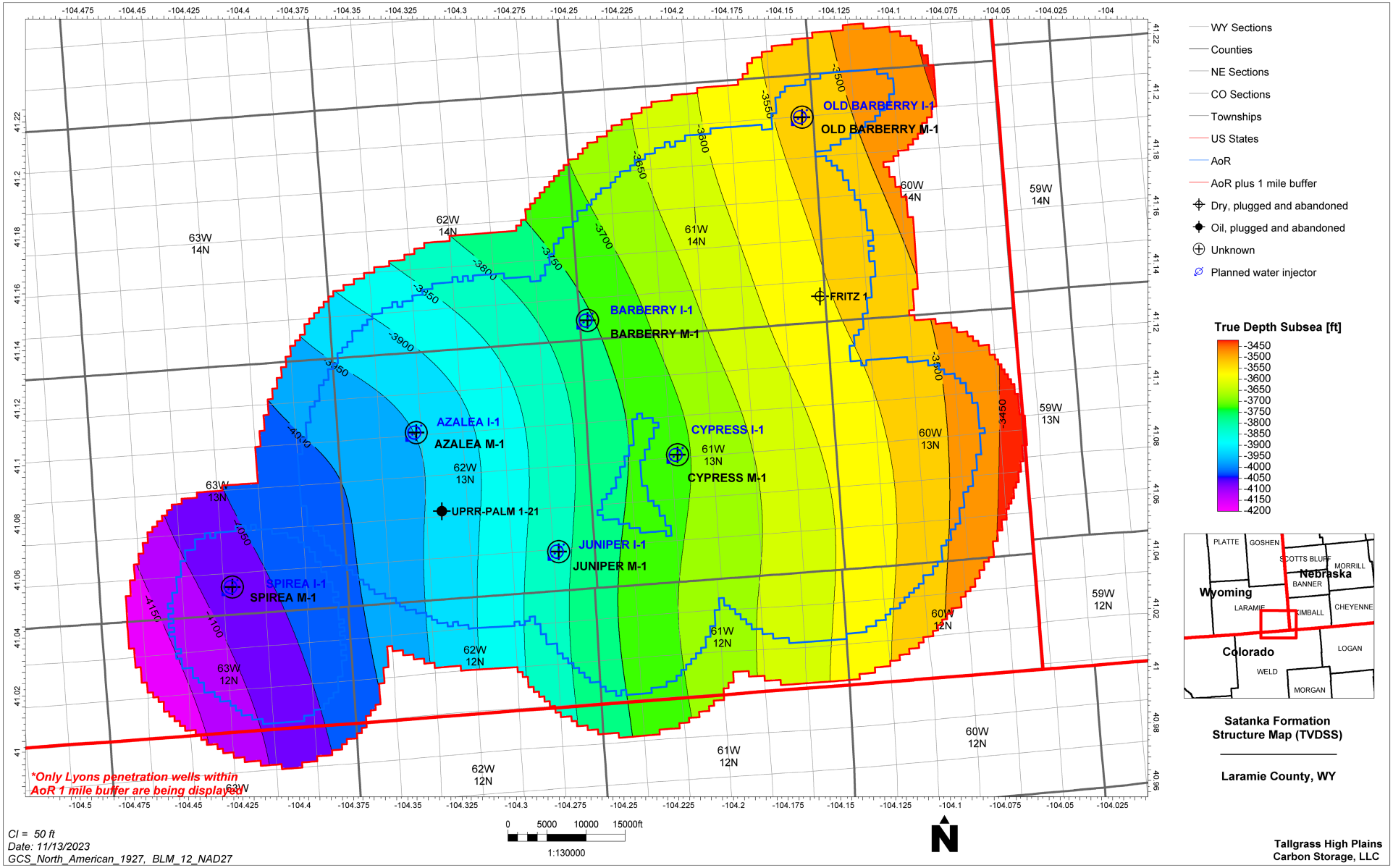


Figure 2.37—Subsea structure map of the lower confining zone, the Satanka Formation.

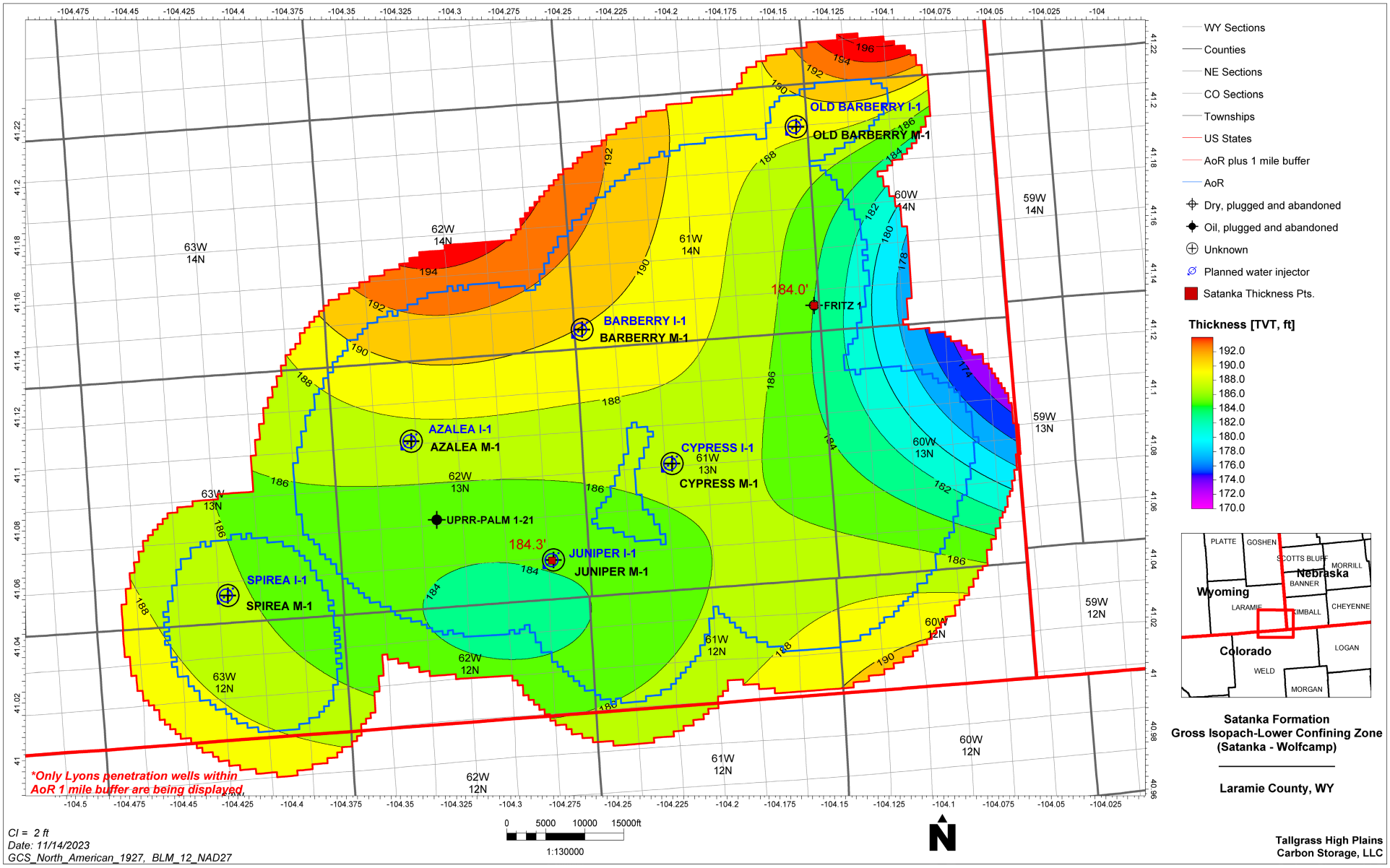


Figure 2.38—Gross isopach map of the lower confining zone, the Satanka Formation.

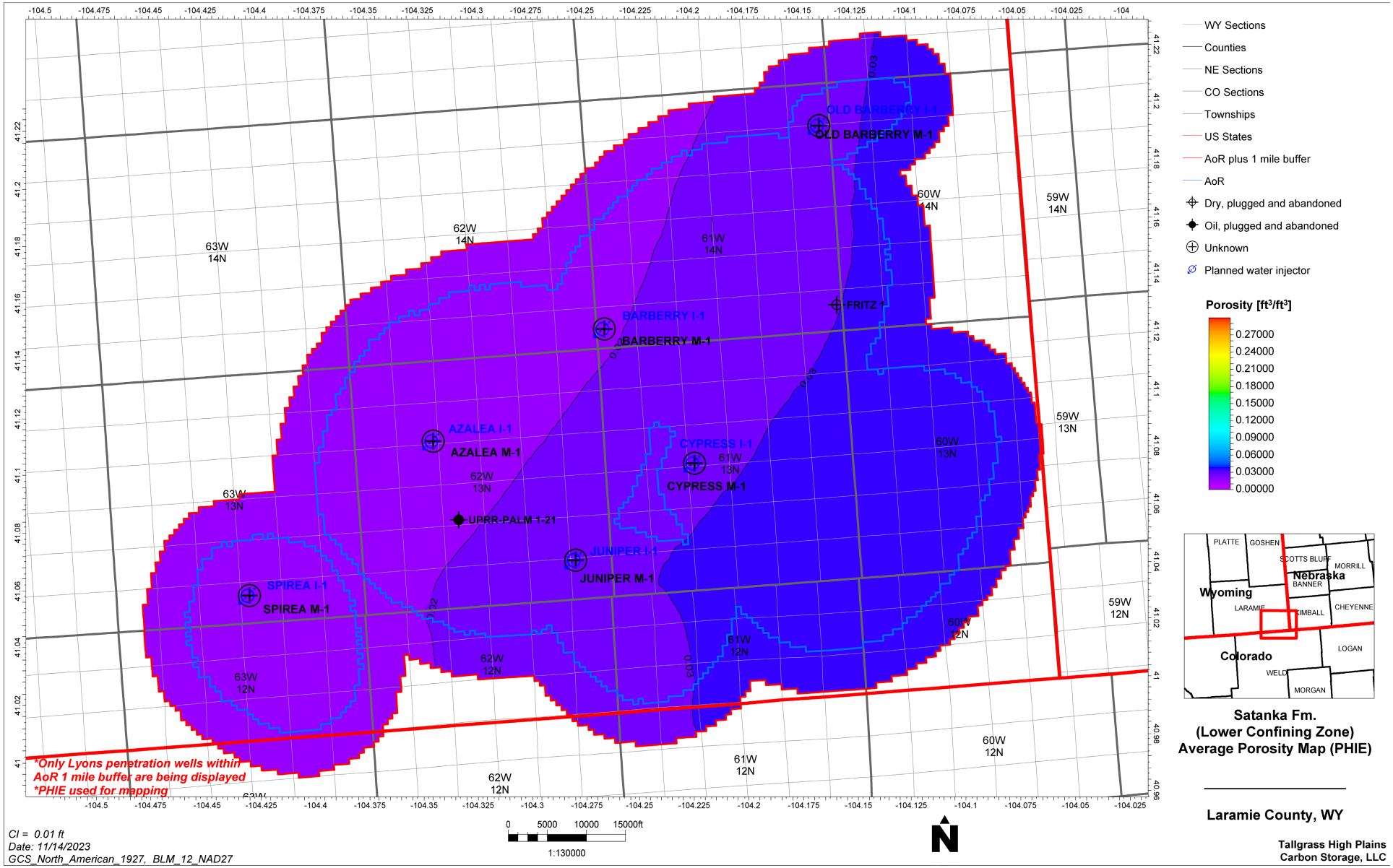


Figure 2.39—Average porosity map of the lower confining zone, the Satanka Formation.

#### 2.4.2.2.1 Mineralogy

Core data were collected from the Satanka Formation during the drilling of Juniper M-1. Core plugs were analyzed using XRD to characterize the mineralogy of the lower confining zone. The XRD mineralogy results are listed in Table 2.27.

Table 2.27—Lower confining zone mineralogy assumptions (based on core XRD of eight samples from the Satanka).

| Mineral | Volume Percent (%) |
|---|---|
| Quartz | 35.8 |
| K-spar | 7.5 |
| Plag. | 6.3 |
| Calcite | 0 |
| Dolomite | 12.8 |
| Siderite | 0 |
| Magnesite | 0 |
| Vaterite | 0 |
| Chlorite | 2.7 |
| Kaolinite | 0 |
| Illite/Mica | 25 |
| Mixed Illite/Smectite | 1.3 |
| Corrensite | 5.6 |
| Talc | 0 |
| Pyrite | 0 |
| Hematite | 0.8 |
| Apatite | 0 |
| Gypsum | 0 |
| Magnetite | 0 |
| Anhydrite | 2.2 |
| **Total Volume** | **100** |

#### 2.4.2.2.2 Geochemical Interaction

A discussion on potential geochemical interactions between the $CO_2$ stream, pore fluids, and host mineralogy of the injection and confining zones is provided in Section 2.4.1.8. A detailed geochemical report, including geochemical interactions, is also provided in the *Appendix L—Geochemical Report*.

#### 2.4.2.2.3 Geomechanical Information of Lower Confining Zone

An industry standard methodology was used to determine fracture gradient of a given rock. For this method, an isotropic model was used based on the dipole sonic log recorded in Juniper M-1.

Further data will be recorded in Juniper I-1 to confirm interpretation from Juniper M-1. Once additional data has been gathered, updated inputs will be incorporated into an anisotropic model that will be used to account for the heterogeneity of the rock. At this time, our best estimate of fracture gradient is 0.58 psi/ft.

#### 2.4.2.2.4 Ductility and Rock Strength

The core elastic properties were measured from two core samples from the lower confining zone. One sample was vertically oriented and the other horizontally oriented. The results are summarized in Table 2.28. The measurements were recorded with a confining pressure of 51.7 MPa or 7,500 psi.

Table 2.28—Satanka elastic properties from Juniper M-1 (additional data to be collected from Juniper I-1 analysis)

| | | | Elastic Properties Measured at Different Confining Pressures | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Well** | **MD (ft)** | **Orientation** | **Conf. (MPa)** | **Diff. (MPa)** | **E (GPa)** | **n** | **K (GPa)** | **G (GPa)** | **P (GPa)** |
| Juniper M-1 | 9,184.45 | Vertical | 51.7 | * | 35.2 | 0.27-0.32 | 19.9 | * | * |
| Juniper M-1 | 9,184.35 | Horizontal | 51.7 | * | 34.6 | 0.22-0.24 | 19.4 | * | * |

E = Youngs Modulus, n = Poisson's Ratio, K = Bulk Modulus, G = Shear Modulus, P = Uniaxial Strain Modulus, * Pending sampling/analysis.

Crushed rock analyses are presented in for Table 2.29 the Satanka Formation which include core plug depths, grain density, core porosity water, oil and gas saturations, and pressure decay (PD) permeability.

Table 2.29—Crushed rock analyses (CRA) for the Satanka. The presence of oil saturation is due to oil-based mud invasion. Reported Pressure Decay (PD) permeabilities were measured from as-received crushed rock samples.)

| Sample ID | Top Depth (ft) | Base Depth (ft) | Grain Den (gm/cc) | Poro (%) | Water Sat (%) | Oil Sat (%) | Gas Sat (%) | PD Perm. (mD) |
|---|---|---|---|---|---|---|---|---|
| 6-37 CRA | 9,183.95 | 9,184.30 | 2.67 | 6.4 | 98.6 | 0.1 | 1.3 | 4.36E-06 |
| 6-47 CRA | 9,193.50 | 9,193.85 | 2.68 | 5.6 | 98.1 | 1 | 0.9 | 3.51E-06 |
| 6-57 CRA | 9,203.00 | 9,203.45 | 2.67 | 4.7 | 97.9 | 0.7 | 1.4 | 4.47E-06 |
| 6-66 CRA | 9,212.00 | 9,212.45 | 2.67 | 5.2 | 98.5 | 0.5 | 1 | 2.71E-06 |
| 6-74 CRA | 9,220.30 | 9,220.85 | 2.69 | 5.3 | 99 | 0 | 1 | 2.73E-06 |
| 6-86 CRA | 9,232.00 | 9,232.45 | 2.73 | 4.9 | 92.9 | 0.2 | 6.9 | 1.74E-05 |
| 6-93 CRA | 9,239.55 | 9,239.95 | 2.66 | 5.1 | 98.2 | 0 | 1.8 | 4.17E-06 |
| 6-112 CRA | 9,258.00 | 9,258.40 | 2.68 | 6.1 | 92.6 | 0.1 | 7.3 | 2.50E-05 |
| 6-117 CRA | 9,263.00 | 9,263.40 | 2.68 | 3.7 | 89.8 | 0 | 10.2 | 1.31E-05 |
| 6-37 CRA | 9,183.95 | 9,184.30 | 2.67 | 6.4 | 98.6 | 0.1 | 1.3 | 4.36E-06 |
| 6-47 CRA | 9,193.50 | 9,193.85 | 2.68 | 5.6 | 98.1 | 1 | 0.9 | 3.51E-06 |
| 6-57 CRA | 9,203.00 | 9,203.45 | 2.67 | 4.7 | 97.9 | 0.7 | 1.4 | 4.47E-06 |
| 6-66 CRA | 9,212.00 | 9,212.45 | 2.67 | 5.2 | 98.5 | 0.5 | 1 | 2.71E-06 |
| 6-74 CRA | 9,220.30 | 9,220.85 | 2.69 | 5.3 | 99 | 0 | 1 | 2.73E-06 |
| 6-86 CRA | 9,232.00 | 9,232.45 | 2.73 | 4.9 | 92.9 | 0.2 | 6.9 | 1.74E-05 |
| 6-93 CRA | 9,239.55 | 9,239.95 | 2.66 | 5.1 | 98.2 | 0 | 1.8 | 4.17E-06 |
| 6-112 CRA | 9,258.00 | 9,258.40 | 2.68 | 6.1 | 92.6 | 0.1 | 7.3 | 2.50E-05 |
| 6-117 CRA | 9,263.00 | 9,263.40 | 2.68 | 3.7 | 89.8 | 0 | 10.2 | 1.31E-05 |

### *2.4.3 Faults, Fractures, and Seismic Activity*

#### *2.4.3.1 Faults and Fracturing*

High Plains conducted a seismic evaluation of ten 2D lines within the region of the EWS Hub, to confirm structural mapping and locate any potential faulting or fracturing within the area (Figure 2.17). The review also incorporated published public domain interpretations of surrounding 3D surveys for Silo Field, North Mustang Field, and Hereford Field. Data for the 3D surveys were not licensed or purchased as the surveys do not cover the proposed Spirea I-1 injection well.

No faults were identified in the seismic evaluation that intersects the plume, or pressure front boundaries (area of review) of Spirea I-1. Faulting was observed in Hereford Field, located seven to eight miles south of the EWS Hub, with a general orientation of east to west. These subsurface features have been evaluated and do not appear to intersect the modeled plume migration or modeled pressure front of Spirea I-1. The Lyons Sandstone is overlain by the Goose Egg and Chugwater confining layers. Together they make up 500 ft of impermeable (<0.01 mD) upper confining zone above the injection zone. The upper confining zone is free of transmissive faults or fractures within the AoR. It impedes vertical fluid migration and allows for pressure dissipation. No additional zones are needed to impede vertical fluid movement.

The seismic review also identified an anomaly located approximately seven to eight miles east of the EWS Hub. The seismic anomaly displayed a sharp boundary of geophysical response, which High Plains interpreted to represent a quick change in lithofacies, faulting, or noise. Noise exhibited within a seismic data set is not representative of actual geophysical properties—and has the potential to affect the resulting seismic interpretation. The seismic anomaly has been evaluated and does not appear to intersect the modeled plume migration or modeled pressure front of Spirea I-1. Orientation of the feature could not be accurately concluded since the anomaly was interpreted from 2D lines.

No faulting was identified from available 2D data within the vicinity of the EWS Hub (Figure 2.17). Specifically, no faulting is shown in the 2D data that intersects the EWS Hub plume that could potentially affect the confinement above or below the Lyons Formation. Hypothetically, faults located south of the EWS Hub could represent deep shear zones associated with the Colorado mineral belt. Pre-Cambrian shear zones have been noted across the DJ Basin and wider Rocky Mountain region. The regional isostatic gravity anomaly map (Figure 2.40) depicts the Colorado mineral belt and identifies the location of the Hereford Field and Silo Field discussed herein. Boundaries of the Colorado mineral belt run from southwest to northeast and suggest that shear zones may extend roughly seven to ten miles south of Spirea I-1. Shear zones contain areas of structural basement weakness that have the potential to be reactivated over time (Downard 2021).

In 2020, Lundstern and Zoback published an article in Nature Communications on multiscale variations of the crustal stress field throughout North America (Lundstern and Zoback 2020). They produced a new-generation stress map of North America by incorporating more than 300 new, measured stress orientations, relative stress magnitudes from earthquake focal mechanisms, and recent fault-slip measurements from almost 2,000 locations. The resulting map, shown in Figure 2.41, has been cropped to cover the Rocky Mountain and Great Plains regions. Stress orientations found closest to the EWS Hub location are generally oriented northwest to southeast and likely represent deformation from shear zones associated with the Colorado mineral belt. These stress orientations agree with the maximum horizontal stress ($SH_{max}$) interpreted from the induced fractures of Fullbore Formation Microimager (FMI) logs run in Logan County, Colorado, just south of the Nebraska border. High Plains ran SLB's oil-based ultrasonic borehole image (UBI) and dipole sonic logs in the Juniper M-1 stratigraphic test well across the injection and confining intervals to gather site-specific stress orientations and an understanding of the transmissive faults or fractures within the injection complex.

No open fractures or faults are observed in the first 35 ft of the Goose Egg formation, which directly overlies the Lyons Formation. The remainder of the confining zones contain occasional partly open and open fractures, none of which are interpreted as being transmissive. Fracture openness is interpreted to be caused by the drilling of Juniper M-1 due to the very limited anisotropic response from the dipole sonic Stoneley waves. Stoneley waves are significantly impacted by the presence of open fractures. Additionally, the dipole sonic tool provides a wider horizontal depth of investigation than the oil-based and ultrasonic image logs, which allows the dipole tool to collect data from a greater horizontal distance in the formation and infer whether open fracturing continues away from the wellbore. The maximum horizontal stress orientation

($SH_{max}$) in the Juniper M-1 well is WNW/ESE based on induced fractures from the UBI interpretation, which is similar to the regional stress (Figure 2.41).

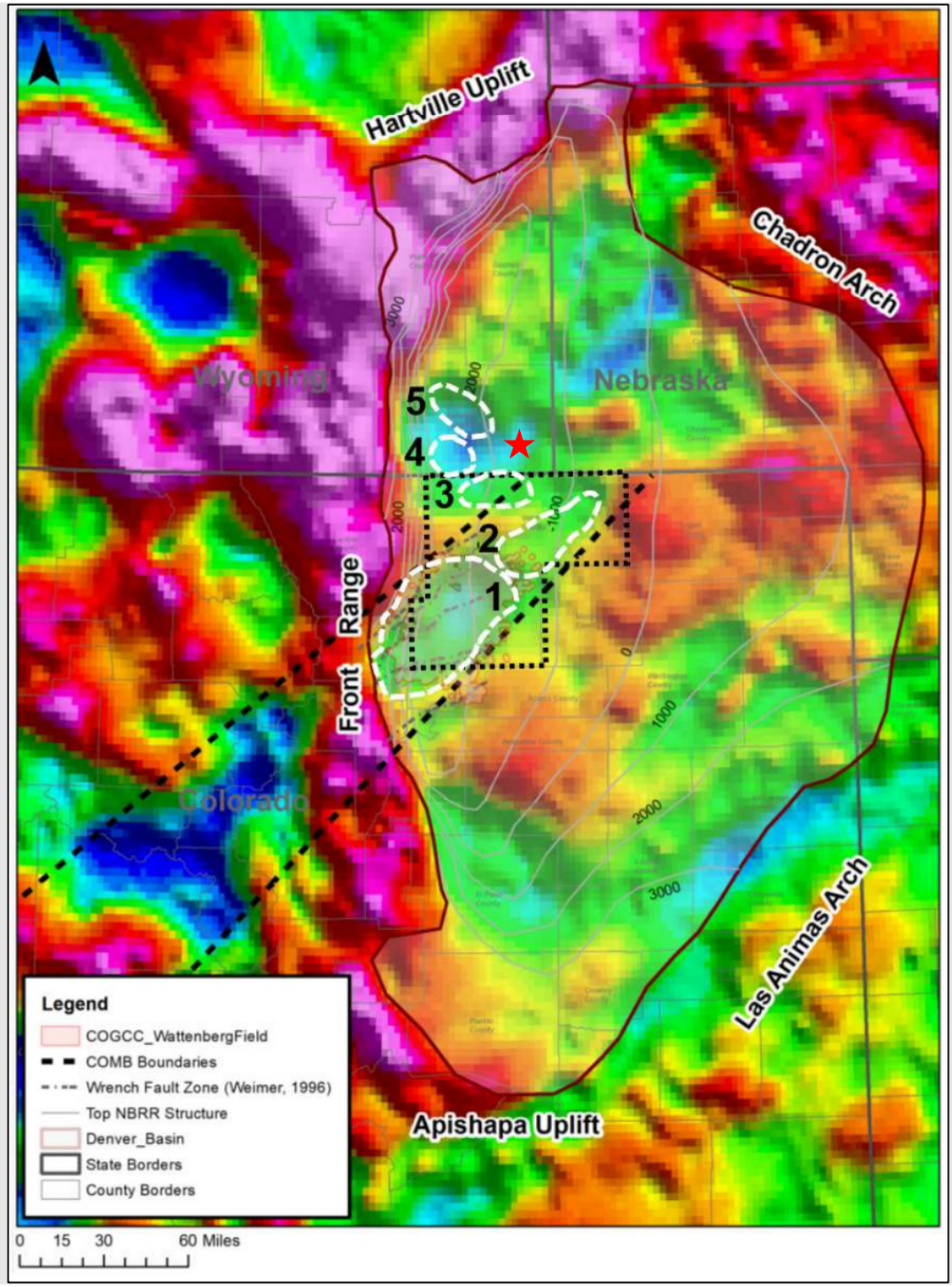


Figure 2.40—Regional isostatic gravity anomaly map depicting the location of Wattenberg (1), Wattenburg Extension (2), Hereford Field (3), Fairway Field (4), Silo Field (5), and Colorado Mineral Belt (COMB), as indicated by the black-dashed lines (Downard 2021). The red star is the approximate location of the EWS Hub.

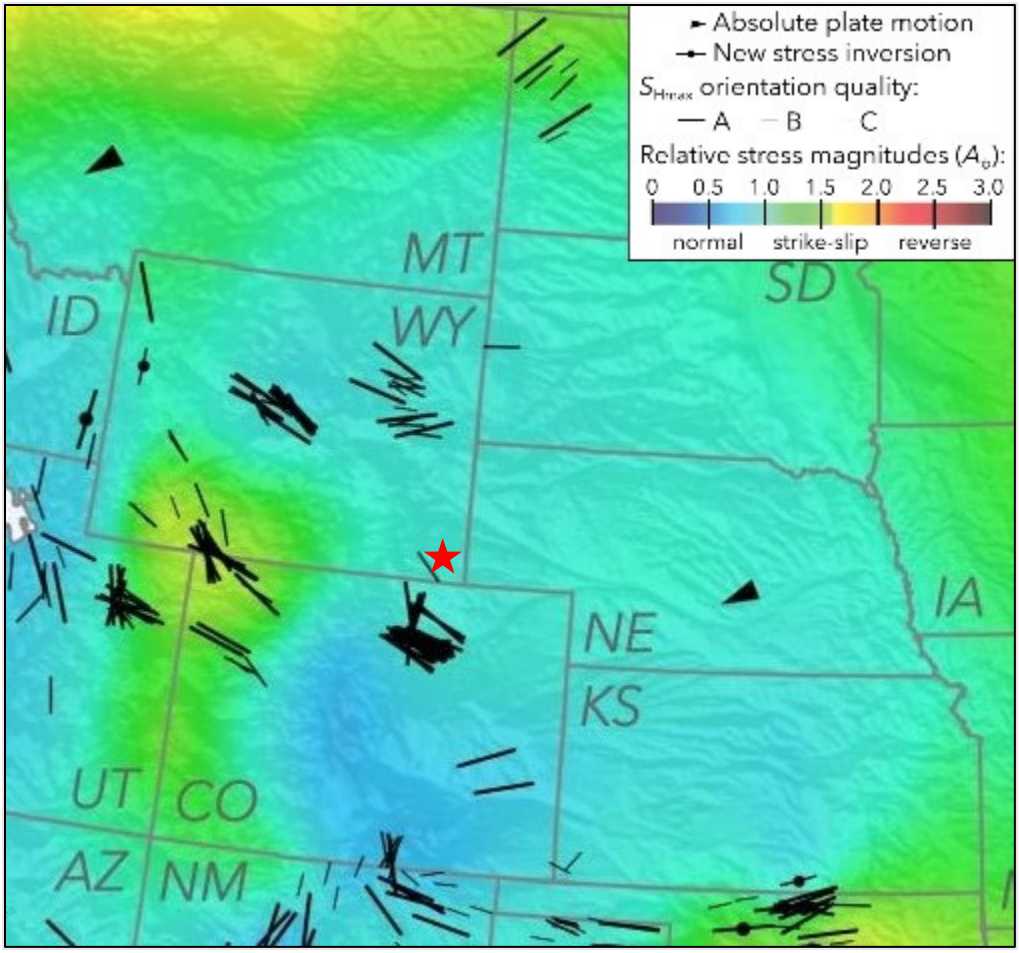


Figure 2.41—Map of the state of stress in North America. The black lines indicate maximum horizontal stress ($SH_{max}$) orientations, which span depths throughout the brittle upper crust. The colored background is the relative stress magnitude/style of faulting. The red star is the approximate location of the EWS Hub (Lundstern and Zoback 2020).

### *2.4.3.2 Seismic Activity*

In 2002, the WSGS published a report on Basic Seismological Characterization of Laramie County, Wyoming. The study analyzed historic seismicity, short- and long-term seismic probability, nearby faulting, and the Uniform Building Code—to improve understating of potential risks of seismicity in Wyoming and their potential to incur damage. Findings from the study suggest the 2,500-year probabilistic map of Wyoming should be referenced for Laramie County seismic analyses, because the map represents a conservative approach in the interest of public safety. The probabilistic acceleration map, shown in Figure 2.42, illustrates that the EWS Hub is located in one of the lowest-risk areas of Wyoming. The contours represent 2% probability of exceedance in 50 years and range from 5%g peak ground acceleration in southeastern Laramie County, to almost 14%g in northwestern Laramie County. Table 2.30 displays the relationship of the Modified Mercalli Intensity relative to peak ground acceleration, perceived shaking, and potential damage (Case et al. 2002).

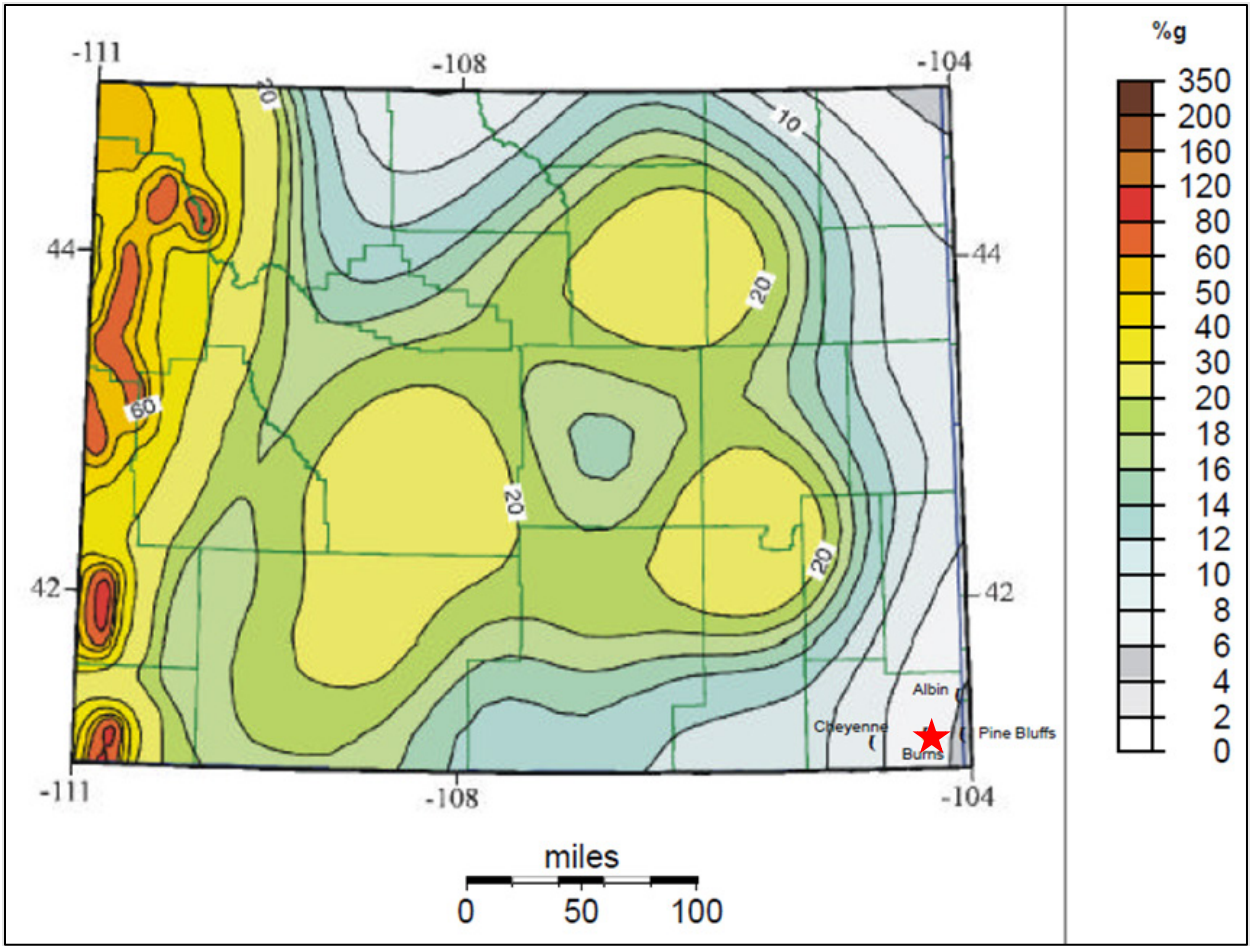


Figure 2.42—USGS 2,500-year probabilistic acceleration map of Wyoming. The contours represent a 2% probability of exceedance in 50 years. The red star is the approximate location of the EWS Hub (USGS 2002).

Table 2.30—Modified Mercalli Intensity relative to peak ground acceleration (PGA), perceived shaking, and potential damage (USGS 2002).

| Modified Mercalli Intensity | Acceleration (%g) (PGA) | Perceived Shaking | Potential Damage |
|---|---|---|---|
| I | <0.17 | Not felt | None |
| II | 0.17 – 1.4 | Weak | None |
| III | 0.17 – 1.4 | Weak | None |
| IV | 1.4 – 3.9 | Light | None |
| V | 3.9 – 9.2 | Moderate | Very Light |
| VI | 9.2 – 18 | Strong | Light |
| VII | 18 – 34 | Very Strong | Moderate |
| VIII | 34 – 65 | Severe | Moderate to Heavy |
| IX | 65 – 124 | Violent | Heavy |
| X | >124 | Extreme | Very Heavy |
| XI | >124 | Extreme | Very Heavy |
| XII | >124 | Extreme | Very Heavy |

Historical earthquake data was obtained from the USGS Earthquake Hazards database, for recorded earthquakes around the proposed Spirea I-1 well in the last 100 years [12]. The search results, shown in Figure 2.43 and Table 2.31, identified no events within 40 miles of Spirea I-1. The nearest Wyoming earthquake occurred on November 23, 2019, approximately 68 miles west-northwest of the center of the AoR, with a magnitude of 2.8 and a focal depth of 3.11 miles. Results of the search also identified several events surrounding the city of Greely, Colorado, approximately 53 miles south-southwest of the center of the AoR. However, modeling conducted by Brown et al. (2017) suggests the seismicity reported in Colorado was due to disposal of wastewater into deep fractured reservoirs near the crystalline basement. The lower confining Satanka Formation is approximately 200 ft thick near the EWS Hub location and is modeled to provide sufficient containment from the crystalline basement. To estimate the potential for induced seismicity, High Plains plans to characterize the stress field in the area and perform fault-stability modeling on any faulting sets identified. Figure 2.43 identifies the location of the EWS Hub relative to seismic events, $SH_{max}$, and proposed monitoring stations.

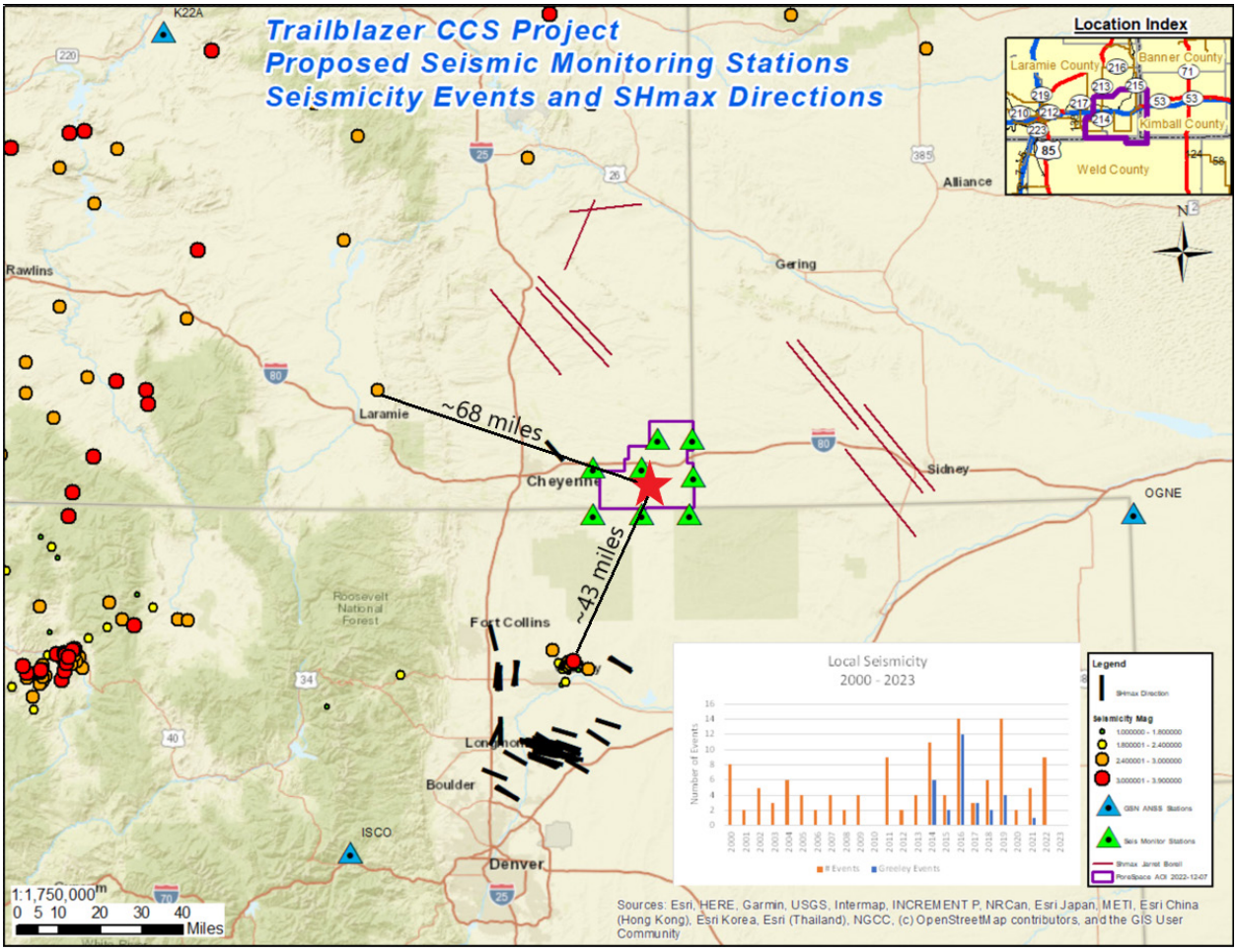

Figure 2.43—USGS-reported earthquakes over the past 100 years. The red star is the approximate location of the EWS Hub.

[12] *retrieved at:* https://www.earthquake.usgs.gov/earthquakes/search

Table 2.31—Summary of earthquakes in Wyoming within a 75-mile radius of EWS Hub.

| Date | Magnitude | Depth (miles) | Longitude | Latitude | City or Vicinity of Earthquake | Map Label | Distance to EWS Hub (miles) |
|---|---|---|---|---|---|---|---|
| 11/23/2019 | 2.8 | 3.11 | -105.504 | 41.411 | 8 miles NNE of Laramie, Wyoming | 1 | 68 |

Available data and reports regarding potential seismicity risk in Wyoming indicate that the EWS Hub is in one of the lowest risk areas of Wyoming, which has experienced very little to no seismic activity over the past 100 years. All identified earthquake events were located more than 40 miles from Spirea I-1. Plume modeling of the Spirea I-1 injection suggests plumes will only migrate several miles in diameter, which results in more than 35 miles between the modeled plume extents and nearest recorded seismic activity. Therefore, the proposed Spirea I-1 injector has a low earthquake risk within the AoR.

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# 3 AREA OF REVIEW

## 3.1 Area of Review Delineation

### *3.1.1 Written Description*

To calculate the extent of the area of review (AoR) (WYDEQ Chapter 24 **§13**), the maximum increase in the reservoir pressure resulting from the injection of supercritical $CO_2$ was evaluated at all points within the model domain, and compared to the critical pressure calculated in *Appendix B*. At no point in the model domain is there sufficient hydraulic potential to lift fluid from the injection zone into the Fox Hills (lowermost confirmed USDW). The AoR was delineated by the extent of the modeled $CO_2$ saturation evaluated at a 2% cutoff. This section demonstrates the reservoir pressure at which fluid could be displaced through a hypothetical pathway and into a USDW, is referred to as "threshold" or "critical" pressure (US EPA 2013). All points within the model domain where the threshold pressure is exceeded, are defined as being within the Project's pressure front. The AoR is defined as "the subsurface three-dimensional extent of the carbon dioxide plume, associated pressure front, and displaced fluids, as well as the overlying formations, and surface area above that delineated region" [Ch. 24 §2(c)], the lateral extent of the AoR herein includes any area where the modeled $CO_2$ saturation exceeds 2% at plume stabilization, or where threshold pressure is exceeded in the injection zone at any time during the modeled timeframe.

The critical pressure was calculated as described in *Section B.9* in *Appendix B*. The plume boundary and pressure front were determined from the dynamic simulation model. The pore occupancy plume is discussed in further detail in *Section 3.4.1*, and the pressure front in *Section 3.4.4.* The results of the static geologic and dynamic simulation models show that the proposed Spirea I-1 well location and geologic storage complex is well suited for carbon storage, containing thick, robust, and continuous confining strata with only three artificial penetrations of the upper confining zone.

The $CO_2$ plume growth after injection is depicted in Figure 3.2. The modeled AoR drifts to the south-southeast due to the structural dip of the formation. Through the modeled timeframe the plume continues growing in this direction until it stabilizes, which has occurred by 2105 (the plume radius is modeled to change by less than 0.15% per year by this time. See Section 4.6.1—Predicted Post-Injection Subsurface Conditions). The maximum extent of the plume used to delineate the AoR is the combination of the extents at plume stabilization (2105—end of post-injection site care/site closure) for the Spirea I-1 and, as the plumes interact, and eventually merge, all other potential offsetting proposed $CO_2$ injection wells.

The reservoir characterization outlined in Section 2.0 demonstrates that the Lyons Formation has sufficient storage capabilities for the planned injection for Spirea I-1. The upper confining zones, the Goose Egg and Chugwater formations, are quality seals as discussed in *Section 2.4.2*

### *3.1.2 Supporting Maps*

Included in this subsection are maps and figures that support the delineation of the AoR. Other information that assisted in this investigation included EWS Hub location, pipelines, proposed injection and monitoring well, $CO_2$ occupancy and pressure plume boundaries, faults, land disturbances, and all existing wells within the AoR and a one-mile buffer.

As discussed in *Appendix B*, the extent of the pressure front at the critical pressure threshold is smaller than the $CO_2$ plume extent, therefore the AoR is determined by the $CO_2$ plume extent.

Maps and cross section included below include:

- Figure 3.1—A pressure map of the EWS hub showing the maximum incremental subsurface pressure influence associated with the injection of $CO_2$. This maximum pressure influence occurs in 2045 (model year 20).
- Figure 3.2—Map showing the extent of the $CO_2$ plume (>2% $CO_2$ concentration) at the end of injection for each well associated with the EWS Hub as well at the plume stabilization (2105, site closure).
- Figure 3.3—Cross sections through the proposed Azalea I-1 location showing $CO_2$ concentration in model year 80—50 years after the end of injection (site closure).

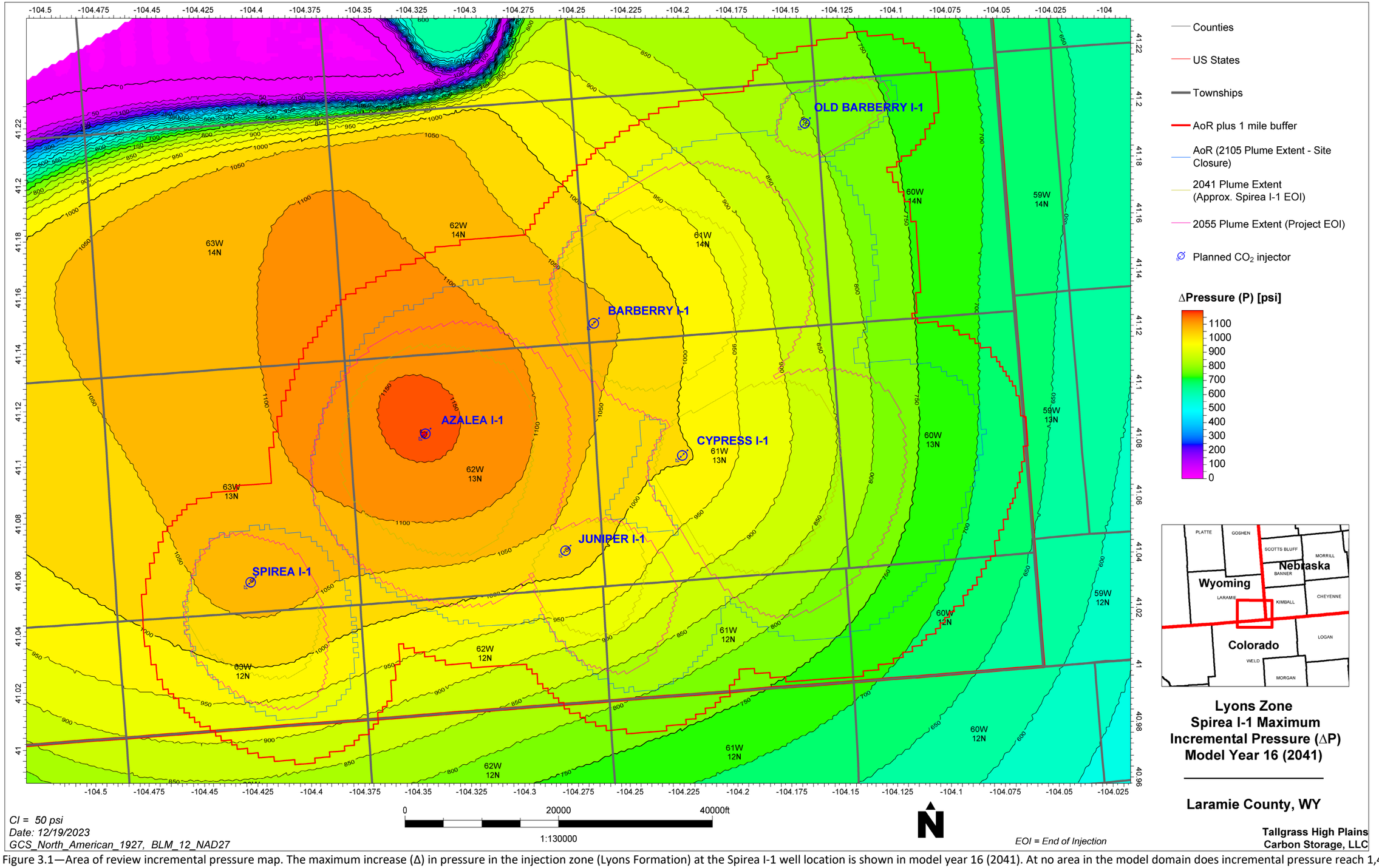



Figure 3.1—Area of review incremental pressure map. The maximum increase (Δ) in pressure in the injection zone (Lyons Formation) at the Spirea I-1 well location is shown in model year 16 (2041). At no area in the model domain does incremental pressure reach 1,402 psi, the critical threshold pressure.

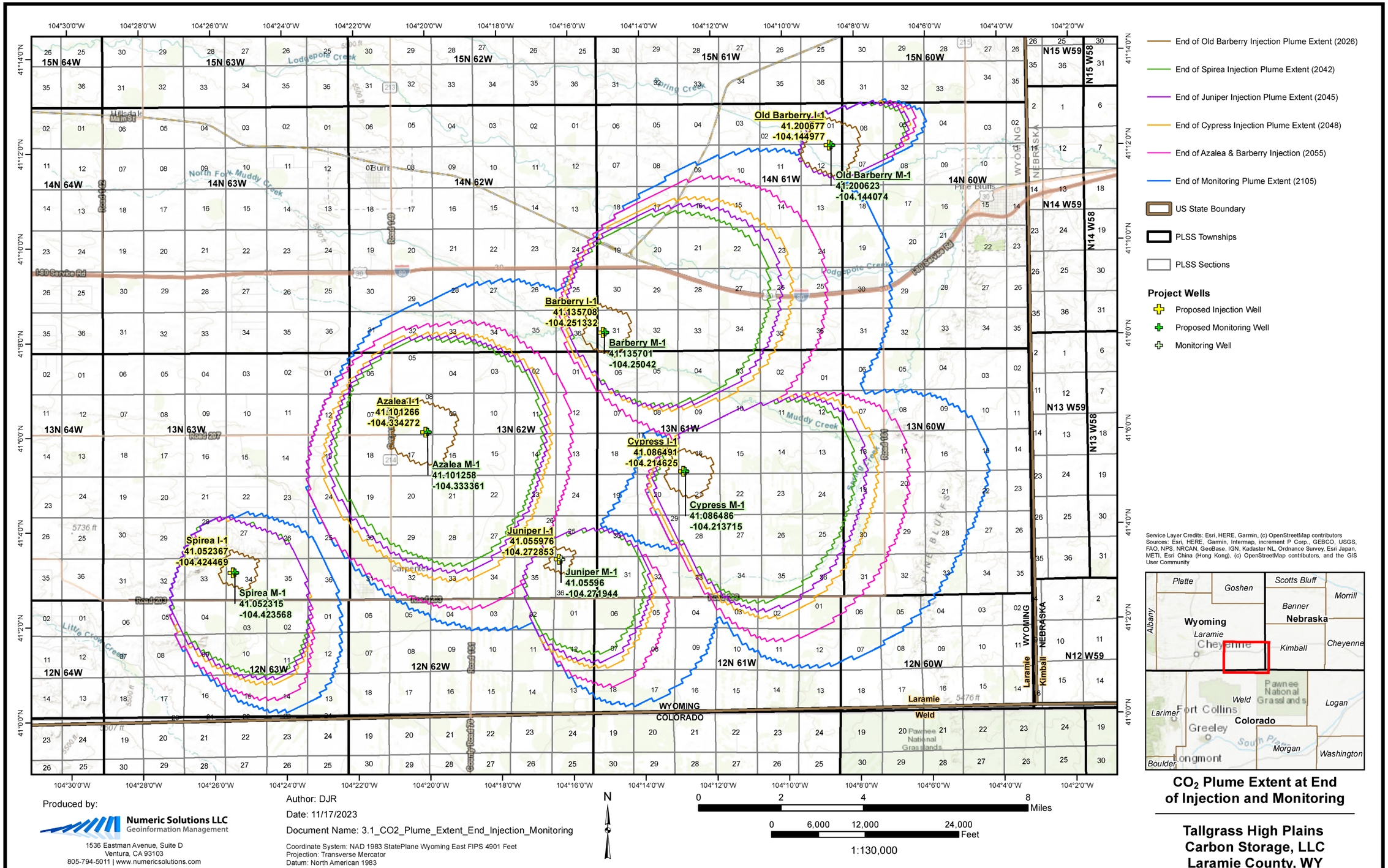



Figure 3.2—$CO_2$ plume extent at end of injection of each proposed injection well and the end of post-injection site care/site closure (2105).

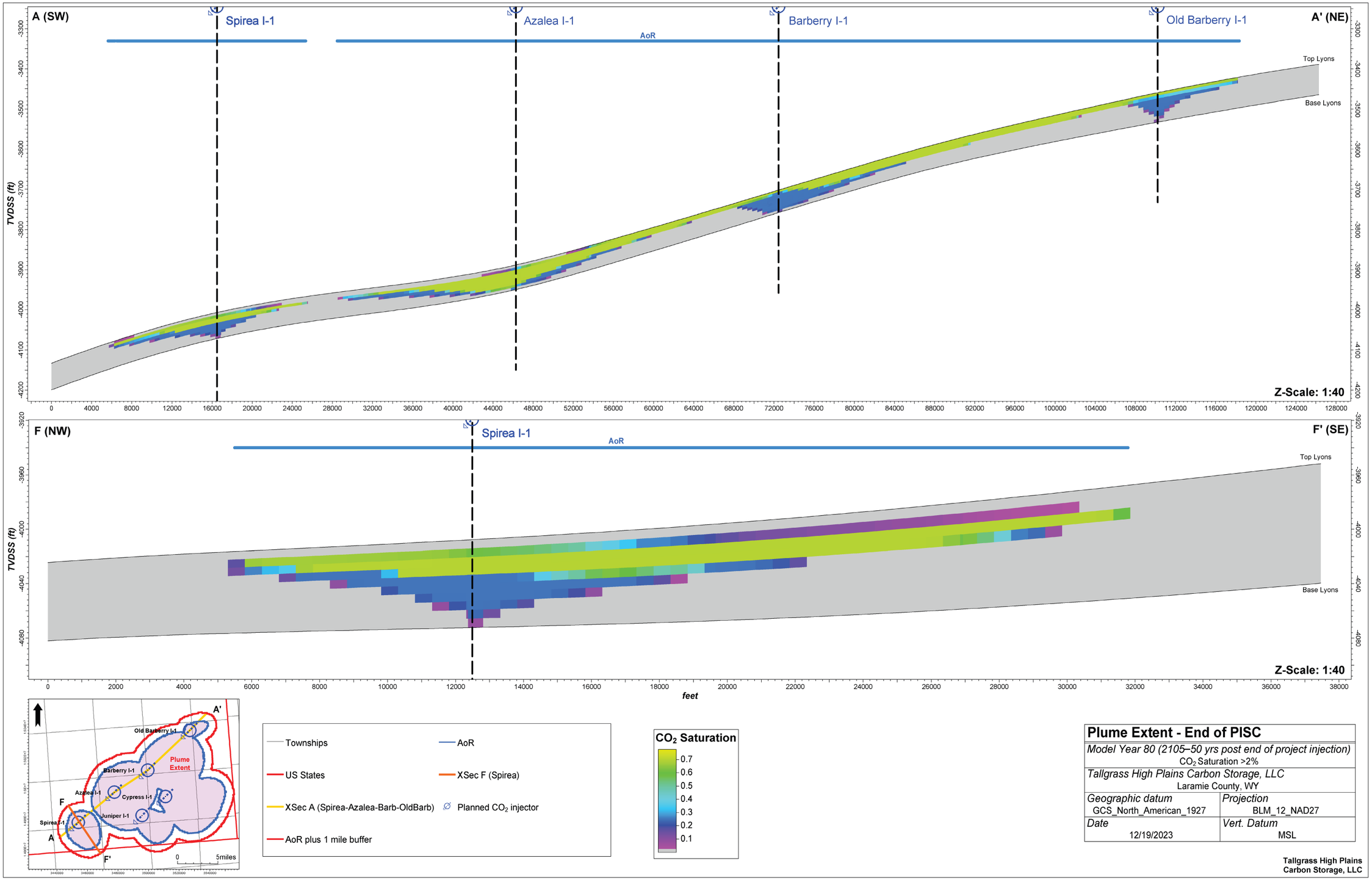



Figure 3.3—Cross sections and $CO_2$ saturation in model year 80 (2105), the end of post-injection site care (site closure).

### *3.1.3 Existing Environmental Permits*

Table 3.1 identifies environmental permits that High Plains will obtain during the development of the EWS Hub.

Table 3.1—Existing environmental permits.

| **Permit Type** | | | |
|---|---|---|---|
| Resource Conservation and Recovery Act (RCRA)—Hazardous Waste Management | Permit No.: | N/A | ☐ |
| UIC—Underground Injection of Fluids | Permit No.: 2022-235 | | ☐ |
| National Pollutant Discharge Elimination System (NPDES)—Discharge of Surface Water | Permit No.: | N/A | ☐ |
| Prevention of Significant Deterioration—Air Emissions from Proposed Sources | Permit No.: TBD | | ☐ |
| Nonattainment Program Under the Clean Air Act | Permit No.: TBD | | ☐ |
| National Emissions Standards for Hazardous Air Pollutants Pre-Construction Approval Under the Clean Air Act | Permit No.: TBD | | ☐ |
| Dredge and Fill Permitting Program Under Section 404 of the Clean Water Act | Permit No.: | N/A | ☐ |
| Other (specify) | Permit No.: | N/A | ☐ |

### *3.1.4 Other Permits*

Table 3.2 identifies additional permits that High Plains will obtain during the development of the EWS Hub.

Table 3.2—Other drilling permits.

| | | | |
|---|---|---|---|
| WOGGC Drilling Permit, Juniper M-1 | Permit No.: 95189<br>(API No. 49-021-29548) | | ☐ |
| WOGGC Drilling Permit, Juniper I-1 | Permit No.: TBD | | ☐ |
| WOGGC Drilling Permit, Barberry I-1 | Permit No.: TBD | | ☐ |
| WOGGC Drilling Permit, Azalea I-1 | Permit No.: TBD | | ☐ |
| WOGGC Drilling Permit, Old Barberry I-1 | Permit No.: TBD | | ☐ |
| WOGGC Drilling Permit, Spirea I-1 | Permit No.: TBD | | ☐ |
| WOGGC Drilling Permit, Spirea I-1 | Permit No.: TBD | | ☐ |
| WOGGC Drilling Permit, Barberry M-1 | Permit No.: TBD | | ☐ |
| WOGGC Drilling Permit, Azalea M-1 | Permit No.: TBD | | ☐ |
| WOGGC Drilling Permit, Old Barberry M-1 | Permit No.: TBD | | ☐ |
| WOGGC Drilling Permit, Spirea M-1 | Permit No.: TBD | | ☐ |
| WOGGC Drilling Permit, Spirea M-1 | Permit No.: TBD | | ☐ |

### *3.1.5 Surface and Subsurface Features in AoR*

Table 3.3 identifies the surface and subsurface features reviewed in the AoR.

Table 3.3—Investigated and identified surface and subsurface features.

| Surface and Subsurface Features | Investigated and Identified In AoR | Investigated But Not Found in AoR |
|---|---|---|
| Producing (Active Wells) | 3 | |
| Abandoned Wells | 52 | |
| Plugged Wells or Dry Holes | 36 | |
| Deep Stratigraphic Boreholes | 1 | |
| Subsurface Cleanup Sites | | X |
| Surface Bodies of Water | | X |
| Other Pertinent Surface Features (including structures intended for human occupancy) | Approximately 481 Agricultural Structures & 190 Residences | X |
| Springs | 8 | |
| Water Wells | 597 | |
| Mines (surface and subsurface) | 13 quarries/mines 4 active | X |
| Quarries | 13 quarries/mines 4 active | X |
| Subsurface Structures (e.g., coal mines) | | X |
| Location of Proposed Wells | X | |
| Location of Proposed Cathodic Protection Boreholes | | X |
| Any Existing Aboveground Facilities | | X |
| Roads | X | |
| State Boundary Lines | | X |
| Tribal Boundary Lines | | X |
| Known or Suspected Faults | | X |
| Other Pertinent Surface Features | | X |
| All Water Quality Management Plan Areas, Wellhead Protection Areas, and Source Water Protection Areas. | X | |

Figure 3.4, Figure 3.5, and Figure 3.6 are maps of surface and subsurface features within the AoR. Figure 3.4 displays the water wells within the AoR plus a one-mile buffer. Figure 3.5 displays the oil and gas wells within the AoR plus a one-mile buffer. Figure 3.6 shows water quality management plan, wellhead protection, and source water protection areas within the AoR. Eight springs are present within the AoR as recorded by The Wyoming Department of Environmental Quality (2023).

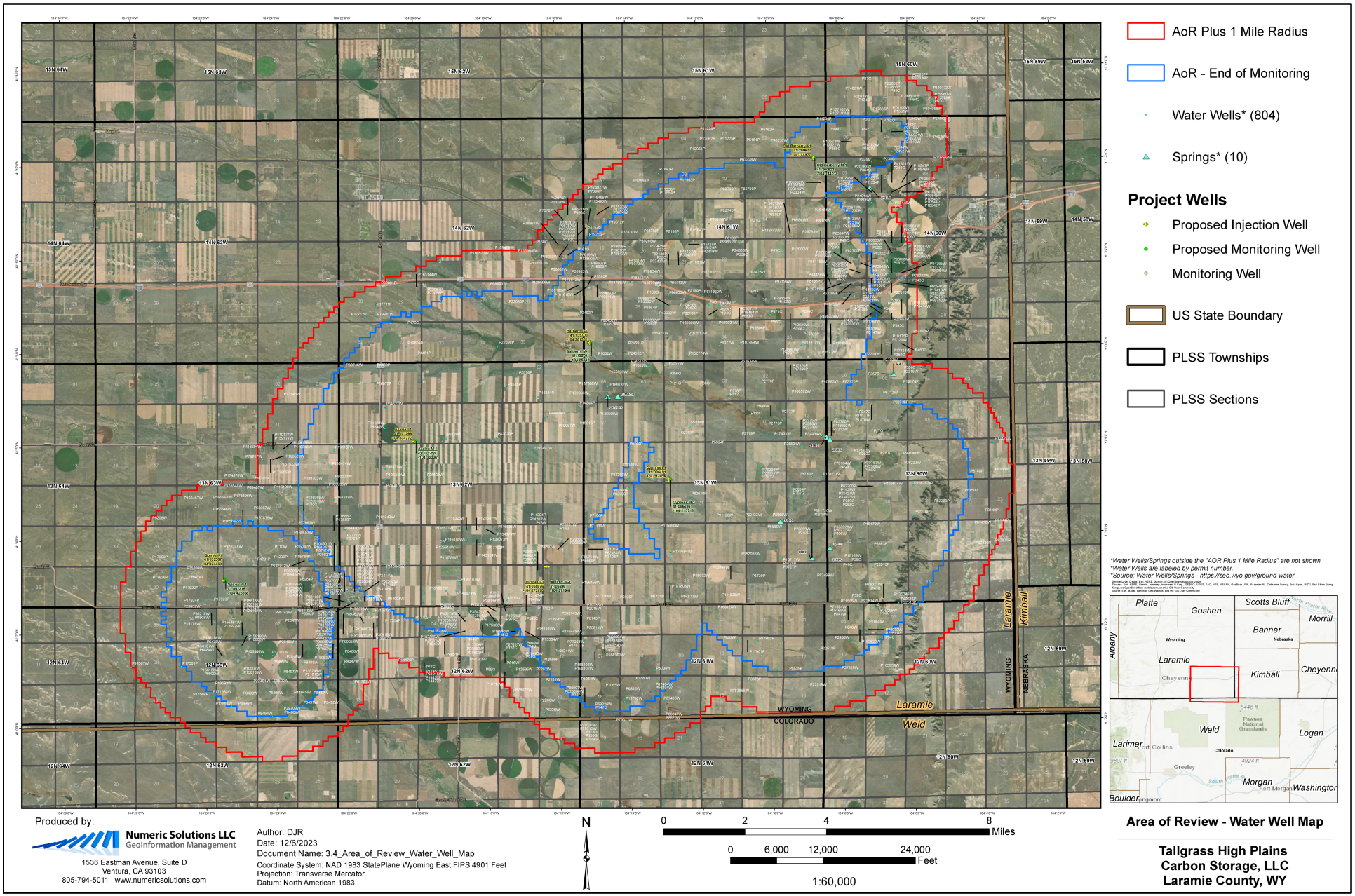



Figure 3.4—Map of water wells within the area of review.

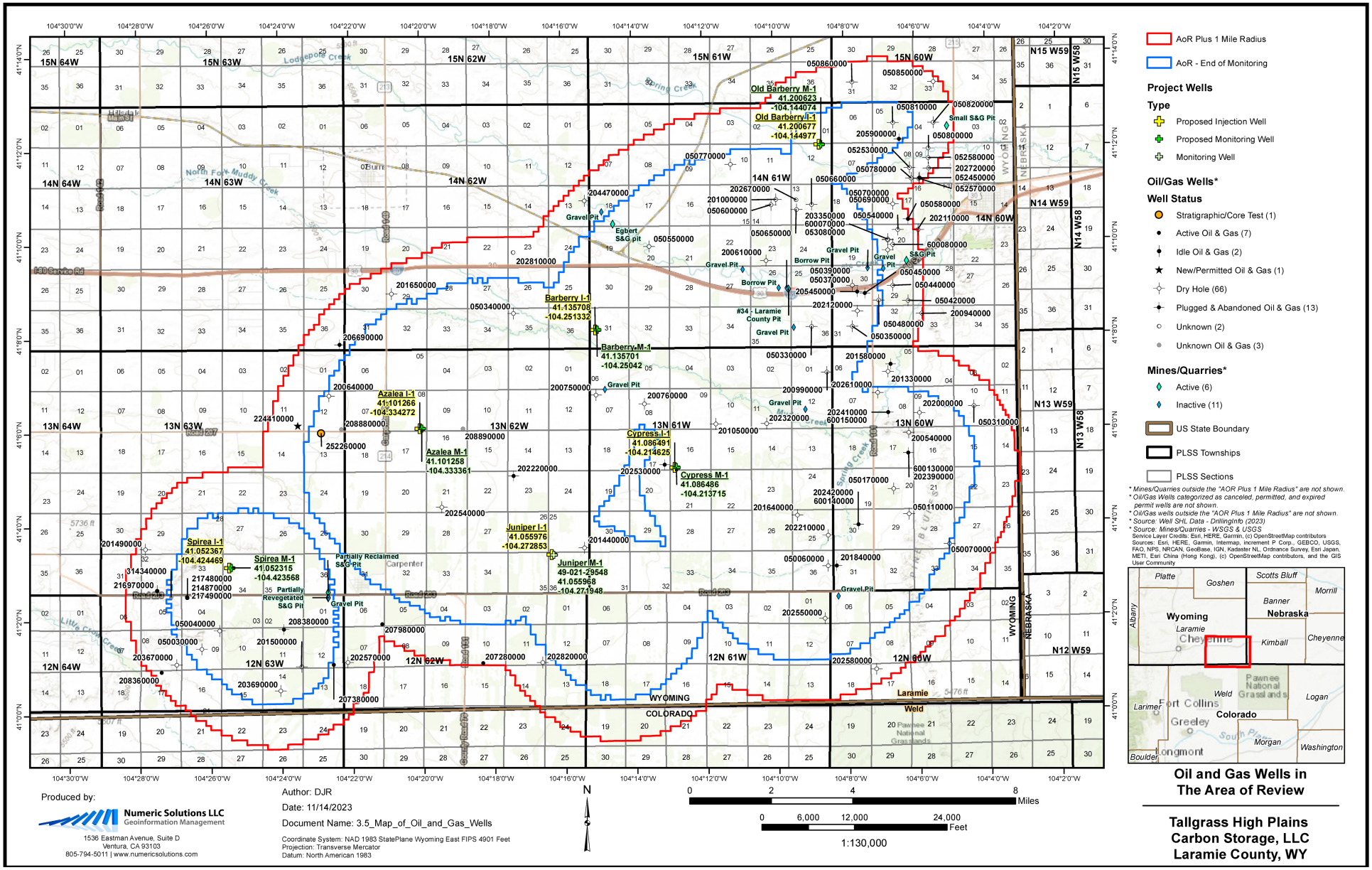



Figure 3.5—Map of oil and gas wells within the area of review.

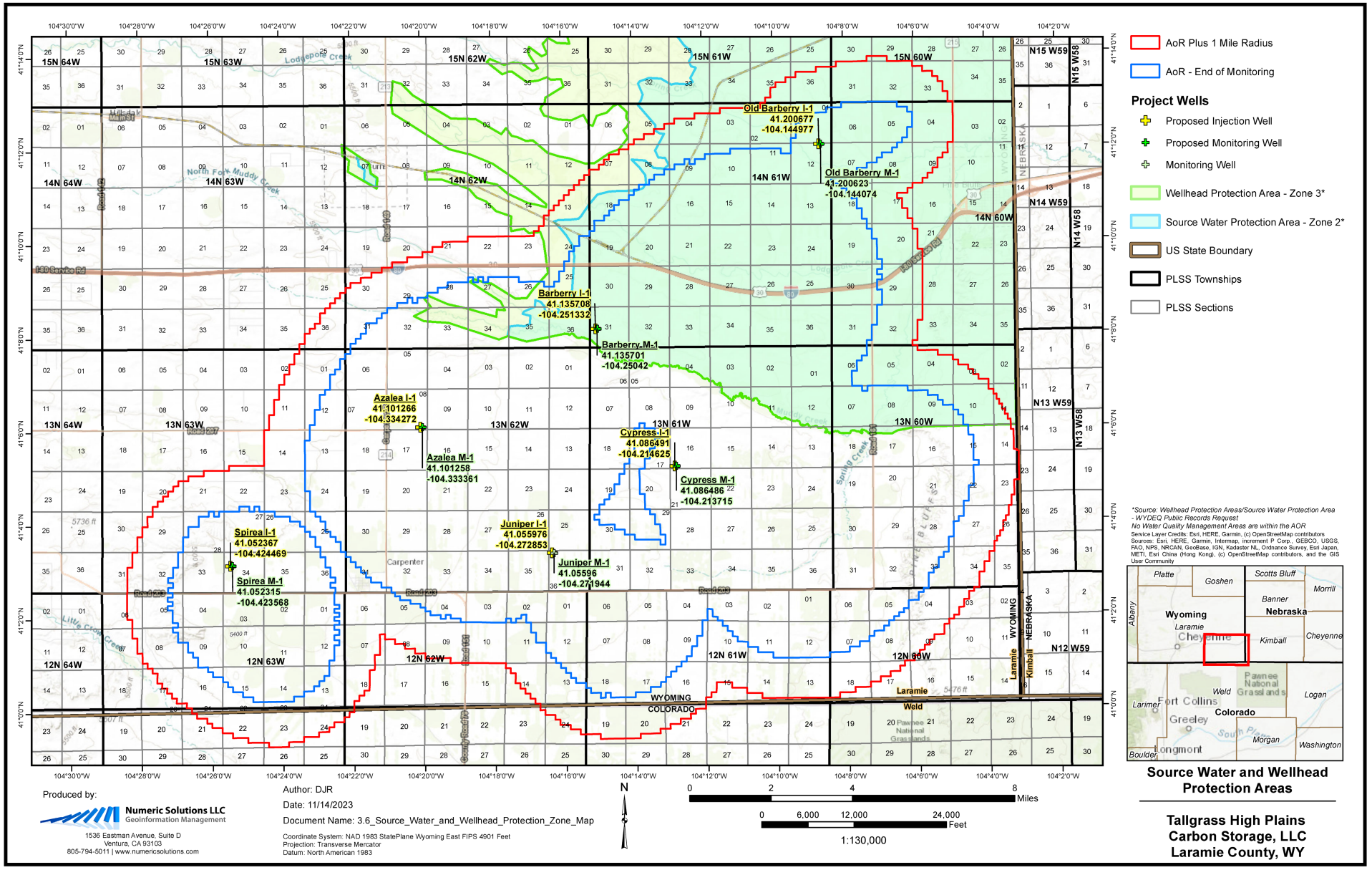



Figure 3.6—Area of review map showing water quality management plan, wellhead protection, and source water protection areas. Data retrieved from deq.wyoming.gov/records-requests accessed July 31, 2023.

An investigation was conducted to evaluate all wellbores drilled within the determined AoR. In total, 57 oil and gas wellbores (52 of which are plugged-and-abandoned) and 597 water wells were found (all of which are listed in *Appendix C*). Of these wells, only 3 penetrate the confining layer within the AoR: Juniper M-1, Fritz 1 and UPRR Palm 1-21. Juniper M-1 is the proposed monitoring well for the Juniper I-1 well and is the characterization well for the EWS Hub. It was constructed with $CO_2$ resistant material. The Juniper M-1 will be plugged back with the high quality $CO_2$ resistant materials above the Lyons injection zone. Fritz 1 and UPRR Palm 1-21 were both drilled and abandoned. They contain no production casing and have adequate cement plugs over relevant zones.

Table 3.4 includes the fifty-seven oil-and-gas wells identified within the AoR. Wells reviewed include injection wells, producing wells, abandoned wells, plugged wells, dry holes, and a deep stratigraphic borehole. These wells do not penetrate the injection zone or confining layer.

Table 3.4—Area of review well information.

| API | Well Name | Location (WGS84) | Operator | Well Status | Depth (ft) |
|---|---|---|---|---|---|
| 49021050030000 | BREEDEN 1-A | 41.02354, -104.43768 | HAYES ROBERTSON DRLG CO | P & A, DRY HOLE | 5,010 |
| 49021050040000 | BREEDEN 1 | 41.029981, -104.429365 | WATKINS J N | P & A, DRY HOLE | 292 |
| 49021050060000 | STATE 53 1 | 41.051041, -104.142931 | SHELL | P & A, DRY HOLE | 7,665 |
| 49021050110000 | CULEK 1 | 41.069075, -104.104708 | WYOMING OIL & DEV CO | P & A, DRY HOLE | 7,544 |
| 49021050170000 | MORRITZ 1 | 41.078112, -104.111715 | WILLIAMS EXPLORATION CO | P & A, DRY HOLE | 7,555 |
| 49021050330000 | FRITZ 1 | 41.136051, -104.149498 | GINTHER, WARREN & GINTHER | P & A, DRY HOLE | 9,015 |
| 49021050340000 | UPRR-ML BASTIAN 1 | 41.141785, -104.289733 | GROSS TODD | P & A, DRY HOLE | 8,031 |
| 49021050350000 | RAUNER 1 | 41.135973, -104.130366 | CHEVRON | P & A, DRY HOLE | 7,756 |
| 49021050370000 | WILHELM 2 | 41.150422, -104.130134 | C M & W DRILLING | P & A, DRY HOLE | 7,480 |
| 49021050390000 | MORRIS 1 | 41.150422, -104.130134 | C M & W DRILLING | P & A, DRY HOLE | 7,449 |
| 49021050450000 | WILHELM 1 | 41.147693, -104.124221 | PAR PACIFIC HOLDINGS | P & A, OIL | 7,462 |
| 49021050480000 | WW DAVIS 1 | 41.14514, -104.11777 | SUNRAY O&G | P & A, DRY HOLE | 8,670 |
| 49021050550000 | ROHRBAUGH 1 | 41.165099, -104.225558 | SLOSS JAMES P | P & A, DRY HOLE | 7,857 |

| API | Well Name | Location (WGS84) | Operator | Well Status | Depth (ft) |
|---|---|---|---|---|---|
| 49021050600000 | ED PRESSER 1 | 41.179401, -104.167961 | LEFTWICH J D | P & A, DRY HOLE | 7,740 |
| 49021050650000 | BARKELL 1 | 41.177596, -104.156025 | TRUE COMPANIES | P & A, DRY HOLE | 7,594 |
| 49021050660000 | GROSS-WILKERSON 1 | 41.179354, -104.148853 | NICKLE L L | P & A, DRY HOLE | 7,540 |
| 49021050770000 | ST JOHN 1 | 41.193866, -104.186895 | JOHNSON D E A INC | P & A, DRY HOLE | 7,701 |
| 49021050810000 | WILKINSON 1 | 41.20813, -104.110154 | WESTLAND ENERGY | P & A, DRY HOLE | 7,625 |
| 49021200540000 | MORITZ BROTHERS 1 | 41.098036, -104.104321 | GROSS TODD | P & A, DRY HOLE | 7,700 |
| 49021200610000 | PROSSER 1 | 41.159578, -104.170609 | GROSS TODD | P & A, DRY HOLE | 7,682 |
| 49021200640000 | MITTAN 1 | 41.113095, -104.376896 | INTERCONTINENTAL PETROLEUM | P & A, DRY HOLE | 8,576 |
| 49021200750000 | UPRR-ROHER 1 | 41.112513, -104.251372 | GROSS TODD | P & A, DRY HOLE | 7,967 |
| 49021200760000 | BUTLER 1 | 41.109168, -104.228575 | GROSS TODD | P & A, DRY HOLE | 7,925 |
| 49021200990000 | UPRC-RESOURCE CORP 1 | 41.119735, -104.142473 | TARGET OIL | P & A, DRY HOLE | 7,636 |
| 49021201000000 | HOBBS 1 | 41.181179, -104.165608 | POLUMBUS CORP | P & A, DRY HOLE | 7,646 |
| 49021201050000 | DOLAN 13-10 | 41.101812, -104.195054 | DIAMONDBACK ENERGY | P & A, DRY HOLE | 7,836 |
| 49021201440000 | CHAMPLIN 325 AMOCO A 1 | 41.058315, -104.257346 | BP | P & A, DRY HOLE | 7,990 |
| 49021201640000 | UPRR-GARDNER BROS 1 | 41.017055, -104.3909 | GROSS TODD | P & A, DRY HOLE | 8,247 |
| 49021201840000 | STATE 12-31 | 41.069149, -104.157084 | CORRIDA OIL INC | P & A, OIL | 7,679 |
| 49021202000000 | GARDNER 13-9 | 41.051036, -104.138821 | DUNCAN OIL | P & A, DRY HOLE | 7,703 |
| 49021202120000 | CARPENTER 1 | 41.105007, -104.099277 | GROSS TODD | P & A, DRY HOLE | 7,700 |

| API | Well Name | Location (WGS84) | Operator | Well Status | Depth (ft) |
|---|---|---|---|---|---|
| 49021202210000 | CHAMPLIN 460 B 1 | 41.141374, -104.127925 | BP | P & A, DRY HOLE | 7,532 |
| 49021202220000 | CHAMPLIN 325 AMOCO B 1 | 41.061902, -104.142846 | DJ RESOURCES INC | P & A, OIL | 7,973 |
| 49021202320000 | CHAMPLIN 460 AMOCO A 1 | 41.08399, -104.2904 | BP | P & A, DRY HOLE | 8,408 |
| 49021202390000 | MORRITZ BROTHERS 1-17 | 41.101751, -104.171156 | ATLANTIC OIL COMPANY | P & A, OIL | 7,810 |
| 49021202410000 | WINTER FARMS 1-8 | 41.090762, -104.104565 | ATLANTIC OIL COMPANY | P & A, OIL | 7,650 |
| 49021202420000 | ALLEN STATE 1-30 | 41.105238, -104.113796 | ATLANTIC OIL COMPANY | P & A, OIL | 7,650 |
| 49021202530000 | UPRR BUTLER 1-17 | 41.065481, -104.12852 | PRIVATE OIL INDUSTRIES | P & A, OIL | 7,650 |
| 49021202540000 | UPRR-PALM 1-21 | 41.087433, -104.219304 | TRANSTEXAS ENERGY | P & A, DRY HOLE | 7,924 |
| 49021202550000 | UPRR HRUSKA FEE 1-1 | 41.07318, -104.324348 | TRANSTEXAS ENERGY | P & A, DRY HOLE | 9,424 |
| 49021202610000 | WINTER FARMS 11-8 | 41.032344, -104.144599 | TERRA ENERGY PARTNERS LLC | P & A, DRY HOLE | 7,798 |
| 49021202670000 | BARKELL 1 | 41.112336, -104.118687 | WORLDWIDE ENERGY CORP | COMPLETED | 7,600 |
| 49021203670000 | BREEDEN 8-16 | 41.181058, -104.156068 | COLE JACK A | P & A, DRY HOLE | - |
| 49021203690000 | GRAHAM 14-11 | 41.008508, -104.400771 | GARY-WILLIAMS PRODUCTION CO. | P & A, DRY HOLE | 7,736 |
| 49021205450000 | WILHELM 2 | 41.148203, -104.12782 | PAR PACIFIC HOLDINGS | P & A, OIL | 7,656 |
| 49021205900000 | DUELLO 34-5 | 41.20225, -104.10725 | BEAR OIL & GAS | P & A, OIL | 7,700 |
| 49021208380000 | KONIG 2-11H | 41.03031, -104.39906 | CCRP OPERATING INC | P & A, OIL | 11,930 |
| 49021208880000 | GORDON 1-12H | 41.10107, -104.37137 | GBK CORPORATION | TA, OIL | 11,984 |
| 49021208890000 | SNEESBY 44-9H | 41.10089, -104.31407 | GBK CORPORATION | TA, OIL | 11,700 |
| 49021214870000 | CARPENTER 523-0428H | 41.04194, -104.44449 | EOG RESOURCES | ACTIVE, OIL | 18,002 |

| API | Well Name | Location (WGS84) | Operator | Well Status | Depth (ft) |
|---|---|---|---|---|---|
| 49021217480000 | CARPENTER 126-0408H | 41.04194, -104.44431 | EOG RESOURCES | ACTIVE, OIL | 17,034 |
| 49021217490000 | CARPENTER 127-0429H | 41.042089, -104.444492 | EOG RESOURCES | ACTIVE, OIL | 17,929 |
| 49021252260000 | ROCK PICK 1 | 41.09971, -104.38082 | OCCIDENTAL PETROLEUM | P & A, STRATIGRAPHIC/CORE TEST | 7,731 |
| 49021295480000 | JUNIPER M-1 | 41.055968, -104.271948 | TALLGRASS HIGH PLAINS CARBON STORAGE,LLC | DUC, UNKNOWN | 9,800 |
| 49021600130000 | MORRITZ BROS 1-17 | 41.090762, -104.104565 | ATLANTIC INTERNATIONAL | P & A, UNKNOWN | - |
| 49021600140000 | ALLEN STATE 1-30 | 41.065481, -104.12852 | ATLANTIC INTERNATIONAL | P & A, UNKNOWN | - |
| 49021600150000 | WINTER FARMS 1-8 | 41.105238, -104.113796 | ATLANTIC INTERNATIONAL | P & A, UNKNOWN | - |

## 3.2 Protection of USDWs

### *3.2.1 Introduction of USDW Protection*

Evaluation of publicly available data and regional studies of southeastern Wyoming resulted (see Section 2.2.1—Regional Hydrostratigraphy) in the Fox Hills Formation, the lower most confirmed USDW, being utilized as the lowermost USDW for the EWS Hub herein [13]. The Chugwater Formation and underlying Goose Egg Formation act as the primary overlying confining zone for the Lyons Formation. Shales and tight carbonates present between the upper confining zone and Fox Hills Formation were identified as aquitards by the WSGS and will provide additional protection of USDWs. Figure 2.2 in the site characterization depicts primary and secondary zones of confinement relative to the stratigraphic column, while Table 2.26 in *Section 2.4.2.1.5* briefly describes additional confining zones with approximate formation tops and thicknesses at the Juniper M-1 characterization well location.

### *3.2.2 Geology of USDW Formations*

The DJ Basin contains 14 potential aquifers identified in the 2013 WWDC Platte River Basin Water Plan Update (Taucher et al. 2013). General lithologic descriptions of potential hydrogeologic units

[13] As discussed in Section 2.2.1—Regional Hydrostratigraphy, High Plains is planning on performing additional analysis, including water sampling in future wells, to confirm that no aquifers underlying the Fox Hills meet the Safe Drinking Water Act's criteria for a USDW.

are provided in *Section 2.2.1* along with supporting information to determine proper USDW designations. Following the review of potential major aquifers, minor aquifers, marginal aquifers, and aquitards identified in the WWDC report, it was determined that the following hydrogeologic units are confirmed as USDWs in the region:

- Quaternary alluvial and terrace deposits
- "High Plains Regional Aquifer System" or "Tertiary Aquifer System"
- Ogallala, Arikaree, and White River formations
- Lance and Fox Hills formations

A 2021 USGS groundwater study of southeastern Laramie County collected groundwater quality samples from three monitoring wells (BR-1, LN-1, and FH-1) and two production wells (FH-2 and FH-3) (Bartos et al. 2021). The resulting TDS from the analysis conducted on the samples is shown in Table 3.5, along with producing aquifer, well name, and sample collection date. The values fall below 500 milligrams per liter (mg/L), classifying the groundwater samples as fresh by the EPA and Wyoming Class I domestic water standards (Bartos et al. 2021). Figure 2.30 identifies USGS monitoring wells relative to the proposed Spirea I-1 injector modeled plume, and illustrates the position of the BR-1, LN-1, and FH-1 wells. Confirmed USDWs and other hydrogeologic units from the review are summarized in the stratigraphic column in Figure 2.12. Additional discussions and data regarding confirmed USDWs and additional aquifers which will be evaluated in the future can be found in *Section 2.2.1*—Regional Hydrostratigraphy.

Table 3.5—TDS values from USGS monitoring wells in southeastern Wyoming (Bartos et al. 2021).

| **Aquifer** | **White River** | **Lance** | **Fox Hills** | **Fox Hills** | **Fox Hills** |
|---|---|---|---|---|---|
| **Well** | BR-1 | LN-1 | FH-1 | FH-2 | FH-3 |
| **Sample Date** | 11/13/2013 | 12/17/2013 | 11/14/2013 | 12/3/2014 | 09/23/2015 |
| **TDS (mg/L)** | 373 | 286 | 384 | 532 | 411 |

### *3.2.3 Hydrology of USDW Formations*

Freshwater aquifers in the EWS Hub Spirea I-1 AoR are restricted to shallow formations that range from Quaternary to upper Cretaceous in age. These include unconsolidated Quaternary surface deposits and aquifers of the Ogallala, Arikaree, White River, Lance, and Fox Hills formations. The schematic cross section depicted in Figure 3.7 illustrates the stratigraphic relationship of the freshwater-bearing formations near the EWS Hub. Figure 3.8 and Figure 3.9 indicate that the Spirea I-1 injection well is likely to encounter Quaternary deposits at the surface. A review of the Platte River Basin Plan (2013) springs database found that no springs exist within the proposed AoR.

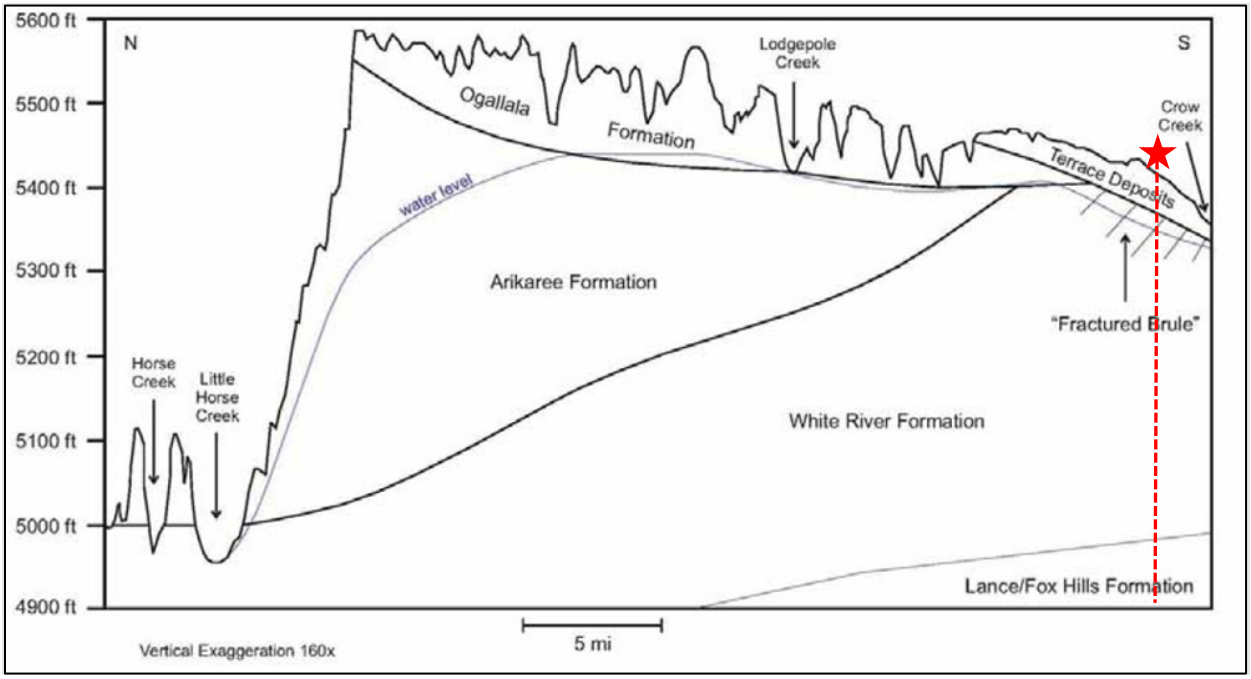



Figure 3.7—North/south schematic cross section located in Laramie County, Wyoming (Brendecke and Hinckley 2014). The red star and line represent the approximate location of Spirea I-1.

Figure 3.8 displays an estimated saturated thickness map of the combined Quaternary, Ogallala, Arikaree, and White River aquifers—commonly referred to as the High Plains aquifer. The map suggests that the saturated thickness of the High Plains aquifer ranges from unsaturated to almost 900 ft thick in Laramie County and will have an approximate thickness of 320 ft thick near the EWS Hub location. Figure 3.9 contains an estimated saturated thickness map of the combined Quaternary, Ogallala, and Arikaree aquifers (same as Figure 3.8, only without the underlying White River Formation) in Laramie County. The saturated thickness in Figure 3.8 varies from 500 ft thick to areas where Ogallala and/or Arikaree formations are absent from the geologic section. The map indicates that these formations are thin or potentially unsaturated within the extents of the Spirea I-1 modeled plume, and most of the saturated thickness within the High Plains aquifer of southeastern Laramie County is comprised of the White River aquifer.

Figure 3.10 depicts a mapped potentiometric surface of the High Plains aquifer system in southeastern Wyoming. The potentiometric surface strikes north-south and generally dips to the

west around the EWS Hub. The groundwater flow direction is estimated to move towards the east within the High Plains aquifer and is visually represented in Figure 3.10 with large blue arrows. A potentiometric surface map of the Lance and Fox Hills formations was not identified in publicly available literature.

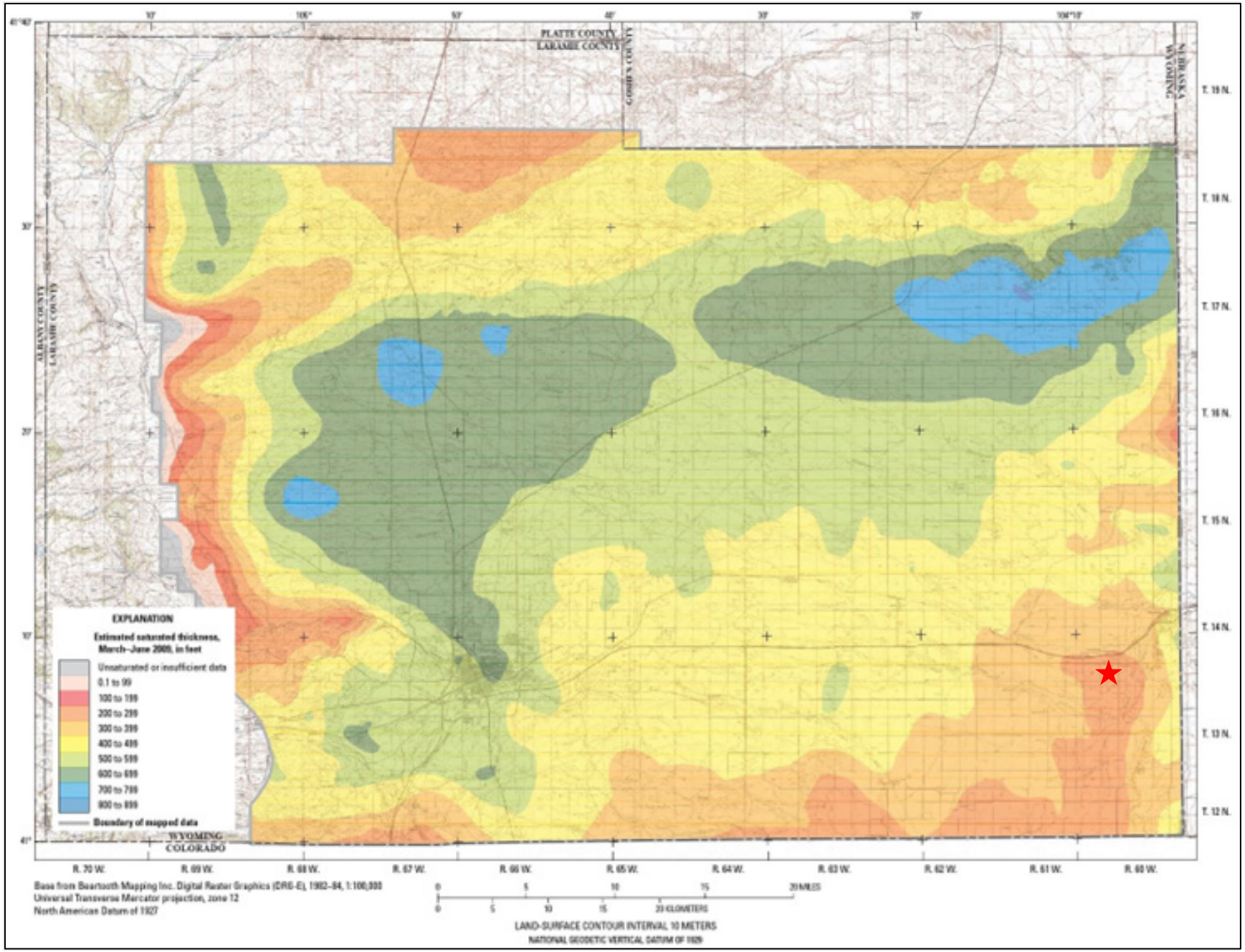



Figure 3.8—Estimated saturated thickness of combined Quaternary, Ogallala, Arikaree, and White River aquifers in Laramie County, Wyoming (Bartos et al. 2021). The red star represents the approximate location of Spirea I-1.

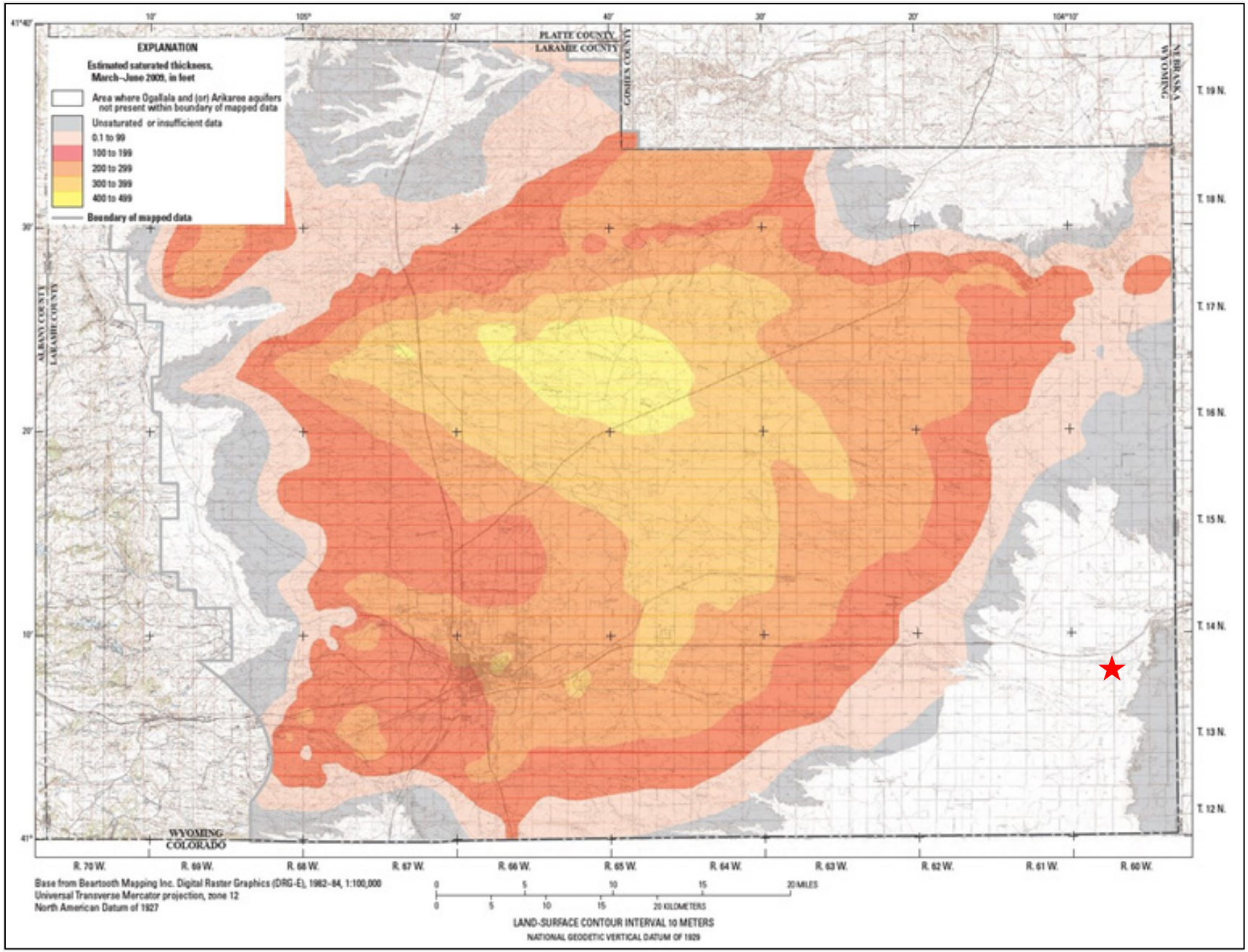



Figure 3.9—Estimated saturated thickness of combined Quaternary, Ogallala, and Arikaree aquifers in Laramie County, Wyoming (Bartos et al. 2021). The red star represents the approximate location of Spirea I-1.

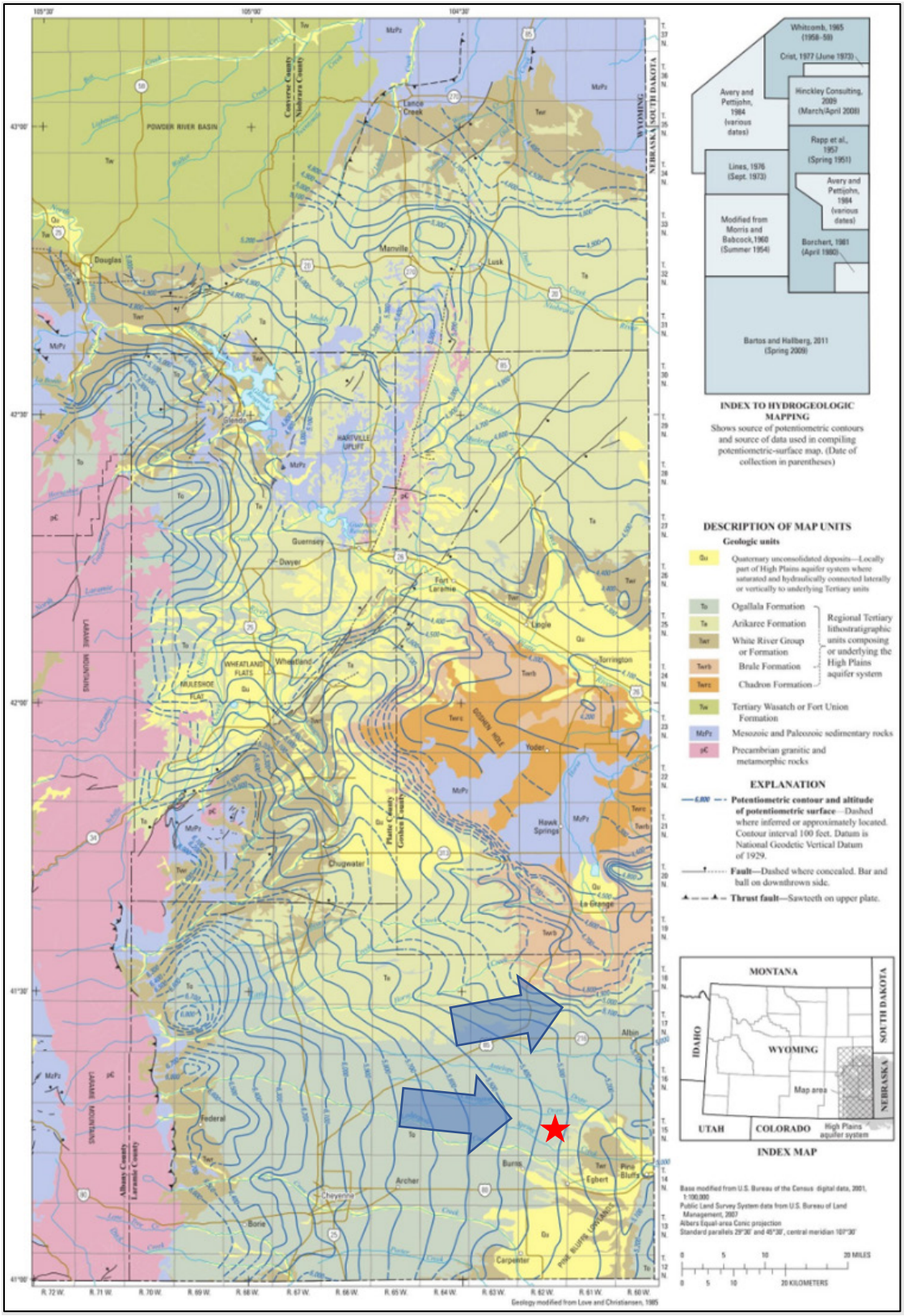



Figure 3.10—Generalized potentiometric-surface map of the High Plains Aquifer System in southeastern Wyoming (modified from Taucher et al. 2013). The red star and line represent the approximate location of Spirea I-1. The blue arrows indicate an estimate of the groundwater flow direction.

The Lance and Fox Hills aquifers underlie the White River Formation of the High Plains aquifer system near the EWS Hub. The USGS cross section shown in Figure 3.11 is constructed with open-hole well logs located near Spirea I-1. The cross section accurately portrays the stratigraphic relationships between the Lance aquifer, Fox Hills aquifer, and Pierre shale within the Project Area. The Fox Hills contains the deepest freshwater aquifer and is the lowermost aquifer exploited for groundwater resource and therefore is the lowermost confirmed USDW at the EWS Hub.

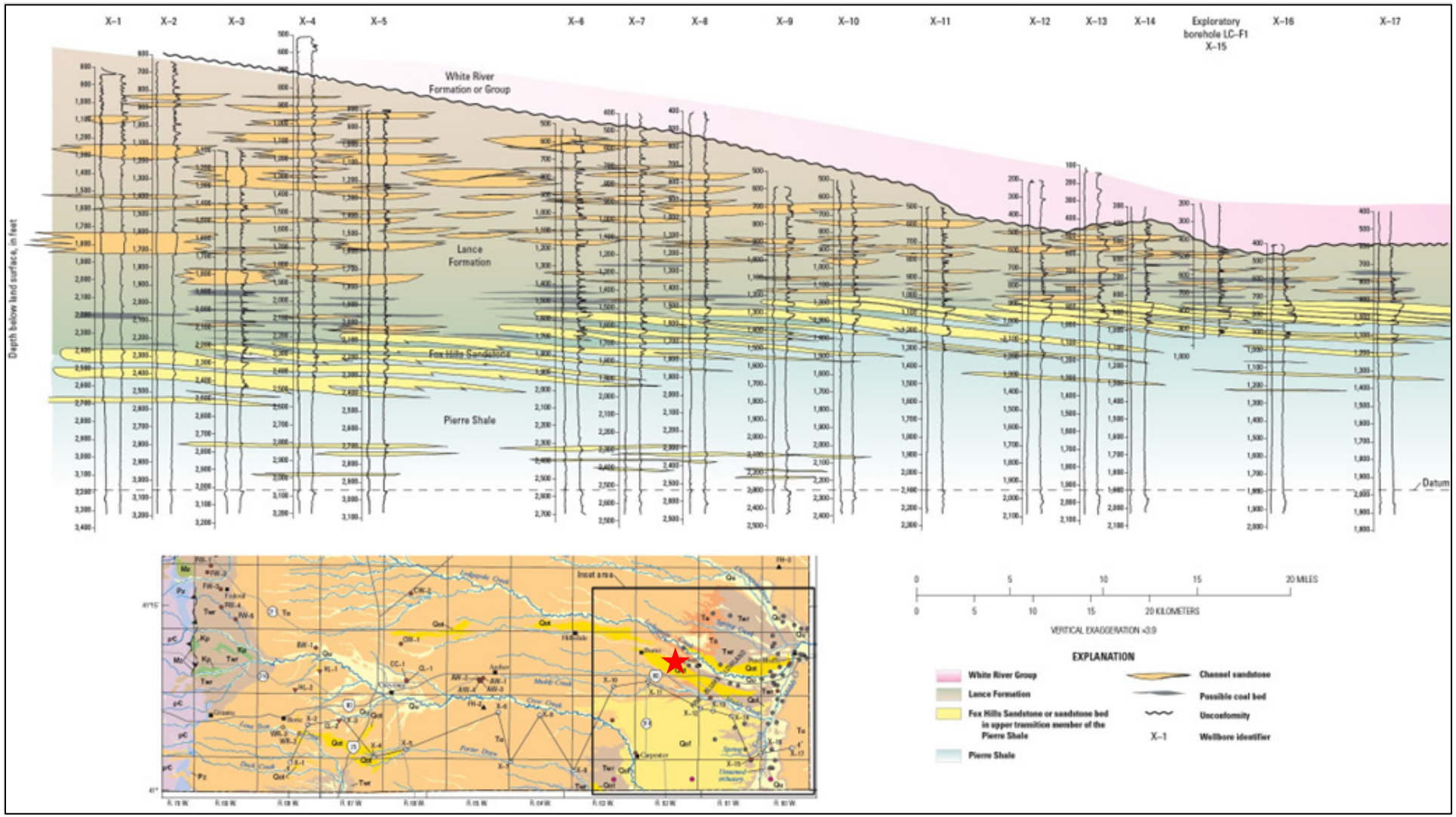



Figure 3.11—Subsurface occurrence of Fox Hills in relation to the Lance Formation and upper transition to Pierre Shale in Laramie County, Wyoming, DJ Basin. (Bartos et al. 2021). The red star and line represent the approximate location of Spirea I-1.

### *3.2.4 Protection of USDWs*

Petrophysical analysis from offsets logs and the Juniper M-1 core indicates the Goose Egg—the formation providing approximately 300 ft as the immediate upper confinement of the Lyons injection interval—has an average effective porosity of 1% and an average gross permeability of 0.01 mD (Table 2.22). Therefore, the Goose Egg Formation contains the physical properties typically required to reduce vertical transmission of fluids and constrain $CO_2$ from migrating out of the injection reservoir. Furthermore, analysis of the Chugwater—the upper confining Triassic formation that overlays the Goose Egg—determined an average effective porosity of 0% and an average permeability of 0.01 mD (Table 2.22). Thus, the Chugwater is a secondary seal should the Goose Egg have a leakage pathway.

Triassic sediments were subsequently overlain by shale and sand deposition that dominated the Jurassic and Cretaceous periods. The Western Interior Seaway was relatively deep and present across a significant portion of western North America during the Cretaceous, including the DJ Basin. Blakey's paleogeographic map in Figure 3.12 displays peak transgression of the Western Interior Seaway that occurred during the late Cretaceous. The long-standing marine environment resulted in deposition of more than 4,000 ft of regionally extensive Cretaceous shale, siliceous shale, and marls between the lowermost confirmed USDW (Fox Hills) and primary upper confining zone. The schematic cross section displayed in Figure 3.13 is oriented across the EWS Hub and provides a visual representation of total Cretaceous sediment accumulation deposited between the upper confining zone and lowermost confirmed USDW. The thick shaly Cretaceous section contains physical properties required to provide additional protection of the confirmed USDWs. A description of additional confinement intervals is provided in Table 3.6.

The Goose Egg and Chugwater formations total more than 500 ft thick and contain high concentrations of shale, silt, salt, or anhydrite in the section that were subsequently overlain by more than 4,000 ft of shale, sandy shale, and marl. These lithologies are known for their profound sealing characteristics and represent the upper confinement zone and additional confinement intervals of the Lyons injection complex. Proposed confining intervals are thick, tight, continuous across modeled plume extents, and contain physical properties necessary to restrict fluid migration. The 2D seismic evaluation referenced in *Section 2.3.4* did not identify any transmissive faults within the plume boundary or pressure front of the proposed Spirea I-1 injection well. Therefore, the geologic section near the EWS Hub is interpreted to provide adequate isolation of confirmed USDW formations from modeled $CO_2$ injection into the Lyons Formation.

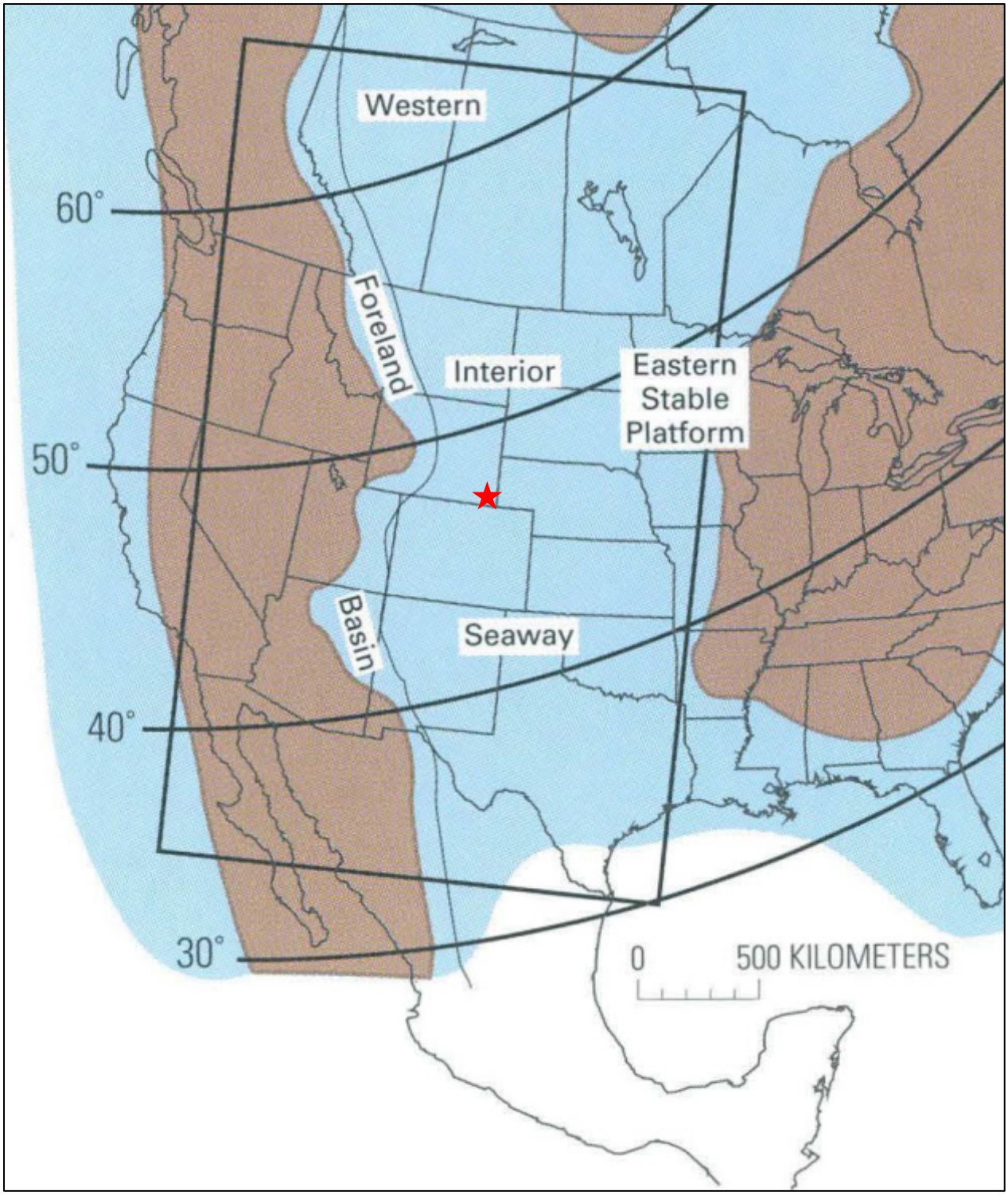



Figure 3.12—Paleogeographic map of the Western Interior Seaway during peak transgression, Late Turonian (Blakey 2014). The red star is the approximate location of the EWS Hub.

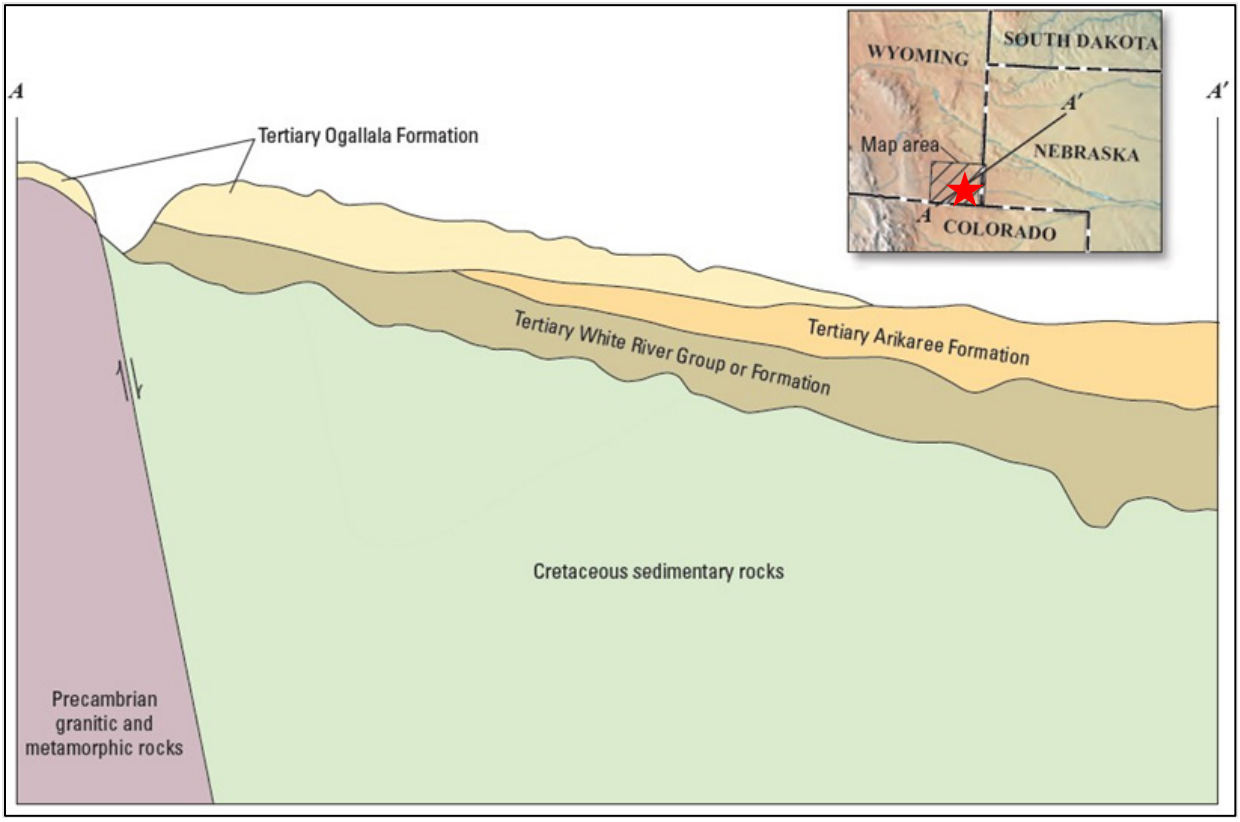


Figure 3.13—USDW southwest to northeast schematic cross section with locator map (Bartos and Hallberg 2011). The red star is the approximate location of Spirea I-1.

Table 3.6—Description of zones of confinement above the immediate upper confining zone.

| Name of Formation | Lithology | Formation Top Depth (ft) | Thickness (ft) | Depth Below Base Lowest Confirmed USDW (ft) |
|---|---|---|---|---|
| Pierre | shale | 1,369 | 5,881 | 0 |
| Niobrara/Carlile | calcareous shale | 7,250 | 508 | 5,881 |
| Greenhorn | shale | 7,758 | 43 | 6,389 |
| Graneros/Belle Fourche | shale | 7,801 | 325 | 6,432 |
| Mowry/Huntsman | siliceous shale | 8,126 | 169 | 6,757 |
| Skull Creek/Thermopolis | shale | 8,375 | 249 | 7,006 |

Local USDW cross sections (Figure 3.15 and Figure 3.16) and a locator map (Figure 3.14) have been included to convey High Plains' geologic interpretation of confirmed USDW formations near the EWS Hub. The cross sections display the geologic section from several hundred feet below

the lowest confirmed USDW to ground level. USDW cross sections are oriented north-south and west-east to present any lateral changes or stratigraphic variability. The geologic section demonstrates consistent structural behavior with the underlying Pierre shale present—well beyond the limits of the EWS Hub. The locator map (Figure 3.14) depicts the location of USDW cross-sectional lines, the Spirea I-1 injection well. Additional discussions and data regarding USDW formations reside in *Sections 2.2.1* through *2.2.3*, and the preceding AoR sections.

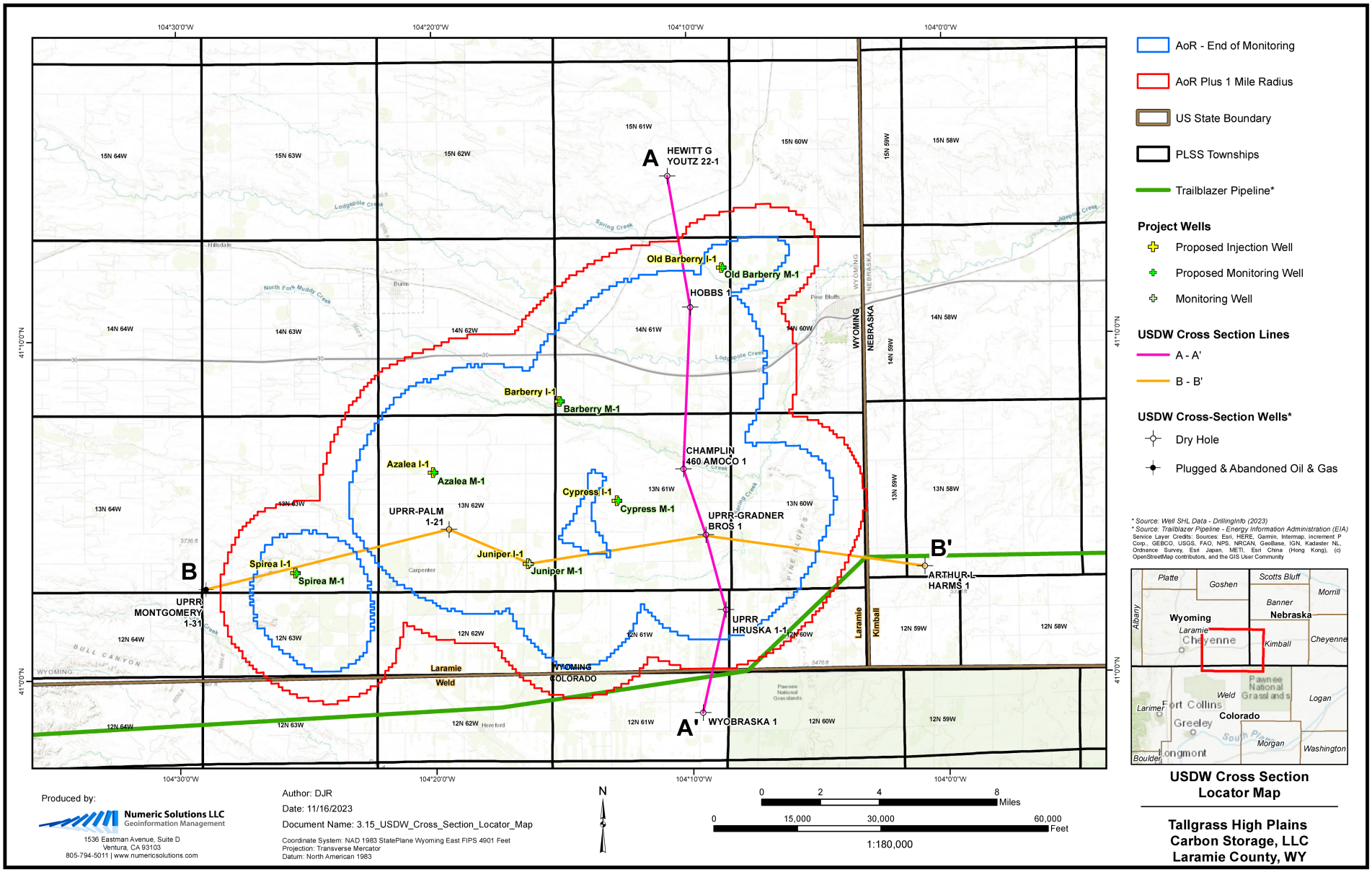



Figure 3.14—USDW cross section index map.

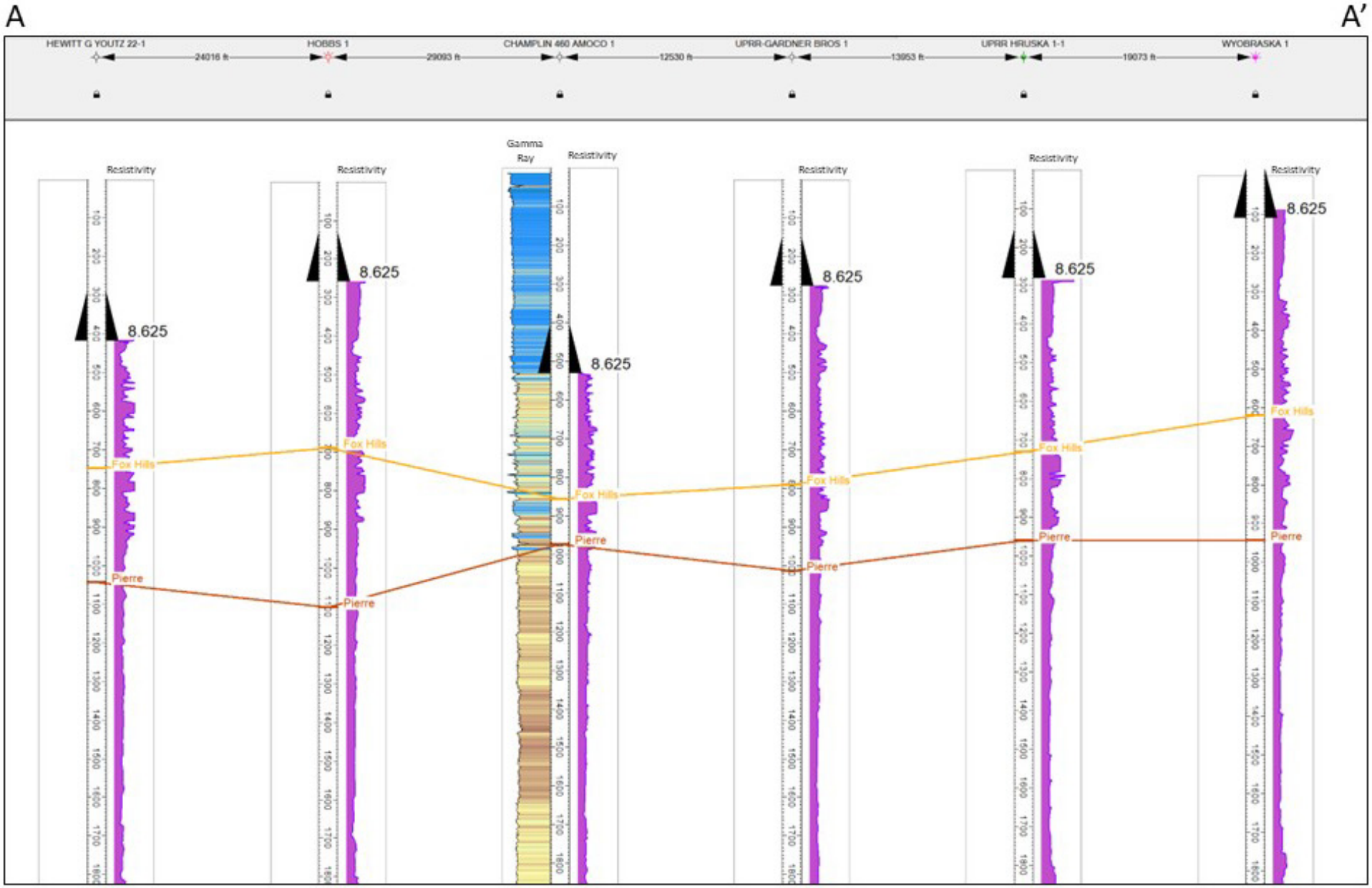



Figure 3.15—USDW north-south cross section A-A' (the Fox Hills Formation is the lowermost confirmed USDW). See Figure 3.14 for location details.

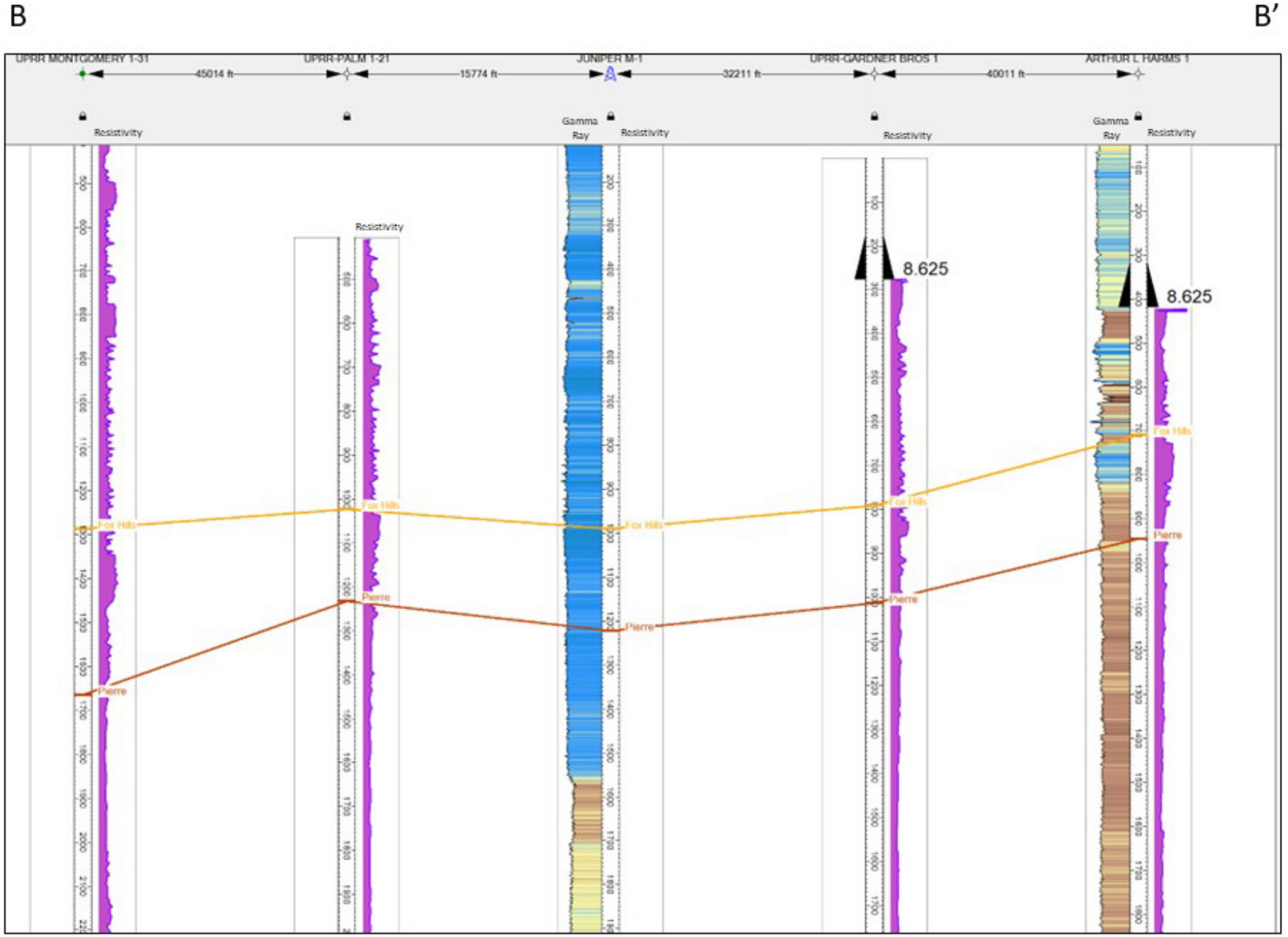



Figure 3.16—USDW east-west cross section B-B' (the Fox Hills Formation is the lowermost confirmed USDW). Groundwater flows from B (west) to B’ (east). See Figure 3.14 for location details.

## 3.3 Corrective Action Evaluation

There are three wells within the AoR plus a one-mile buffer that penetrate the upper confining zone: Juniper M-1 (API #: 49-021-29548), Fritz 1 (API #: 49-021-05033) and UPRR Palm 1-21 (API #: 49-021-20254). Juniper M-1 was drilled by High Plains as a reservoir characterization/stratigraphic test well and was constructed with $CO_2$ resistant material. Fritz 1 and UPRR Palm 1-21 were both drilled and abandoned and do not contain production casing. UPRR Palm 1-21 contains adequate cement plugs across relevant formations and does not require corrective action. Fritz 1 does not provide cement plugs $\leq$ 2,500 ft apart as per the current WOGCC abandonment regulations (Section 18, Form 4) and will need to have remedial work prior to $CO_2$ injection.

In accordance with Chapter 24 Section 13(b)(v), and prior to commencing injection, the Juniper M-1 will be plugged back above the injection (Lyons) and confining zones (Goose Egg/Chugwater) in a manner that will "prevent the movement of fluid into or between USDWs." Following plugging-back, the well is proposed to be used as an above zone monitoring well. It will monitor the first permeable zone above the confining zone (Sundance Formation) and above (including shallow groundwater) for Juniper I-1 via fiber optics, gauges, and pulsed neutron logging (PNL). The plugback will be conducted in a manner exceeding all state regulations to ensure restoration of the confining zones. Further, "materials compatible with the carbon dioxide stream" will be selected.

## 3.4 Plume Model

A representation of the reservoir was constructed from available well logs and interpreted formation tops. The subsurface data was modeled using SLB's Petrel™ software to form a static geocellular model of discrete layers including the Chugwater and Goose Egg (top seals), the Lyons Formation (injection zone), and Satanka Formation (bottom seal). The dynamic geocellular model is comprised of approximately 14 million, 500 ft by 500 ft (IJ), hexahedral grid cells and encompasses an area of 5,800 square miles. Reservoir rock properties are geostatistically distributed in the Lyons Formation.

The geologic model is an input for GEM, a commercial compositional finite difference reservoir simulator, maintained and distributed by the Computer Modeling Group (CMG). GEM is one of the most technically sound reservoir-simulation software packages and is best suited to the compositional nature of carbon dioxide injection and storage. GEM utilizes equation-of-state (EOS) algorithms and advanced computational methods to evaluate key characteristics of fluid flow in the reservoir to produce accurate and dependable simulation models for carbon sequestration. Numerical simulations were run to forecast the subsurface behavior of supercritical $CO_2$, pressure buildup from $CO_2$ injection, and to output parameters, such as pressure and $CO_2$ saturation, used in the evaluation of the AoR.

### *3.4.1 Conceptual Site Model*

The data sources used to construct the static geocellular model include well logs, 2D seismic data, and elements drawn from available literature.

As discussed in *Section 2.3.2*, regional and reservoir-specific publications allowed High Plains to perform petrophysical analysis on offset wells to effectively evaluate the potential injection reservoirs and confining zones within the overall section. Log analysis was performed on a total of 47 wells within the region (*Appendix I*). The analyzed wells were then incorporated into the static geomodel and used to correlate formation tops and calculate formation properties, such as porosity, permeability, and salinity. Publicly available open-hole log data used in the static geomodel, included gamma-ray, spontaneous potential, resistivity, porosity (sonic, neutron, density), photoelectric factor, formation imager, caliper, sidewall core, whole core, or any related analyses.

Available 2D seismic data was calibrated using well ties and was used to further search for evidence of faulting, structural changes, and reservoir thickness not identified from well logs. *Section 2.3.7* further elaborates on how seismic data was incorporated into the static model.

Core samples taken at the Juniper M-1 well directly measured site specific relative permeability, porosity, and capillary pressure in the Goose Egg, Chugwater, and Lyons formations. These data have been incorporated into the geomodel.

There are no known transmissive faults, or fractures in the AoR to incorporate in the model. The Fritz 1, UPRR Palm 1-21, and the Juniper M-1 stratigraphic test well are the only existing artificial penetrations of the confining zone within the AoR. The proposed injection wells are designed to meet and exceed the standards required to prevent corrosion of the construction materials and migration of formation fluids beyond the confining zones.

Petrophysical analysis from well logs acquired in 47 wells were used to determine reservoir rock properties. These wells act as control points in the geocellular static model and were used to distribute porosity and permeability values. Property distribution consisted of applying the kriging algorithm from upscaled porosity logs guided by variograms determined via data analysis for each zone. Figure 3.17 highlights the porosity distribution implemented into the model using simple kriging methodology.

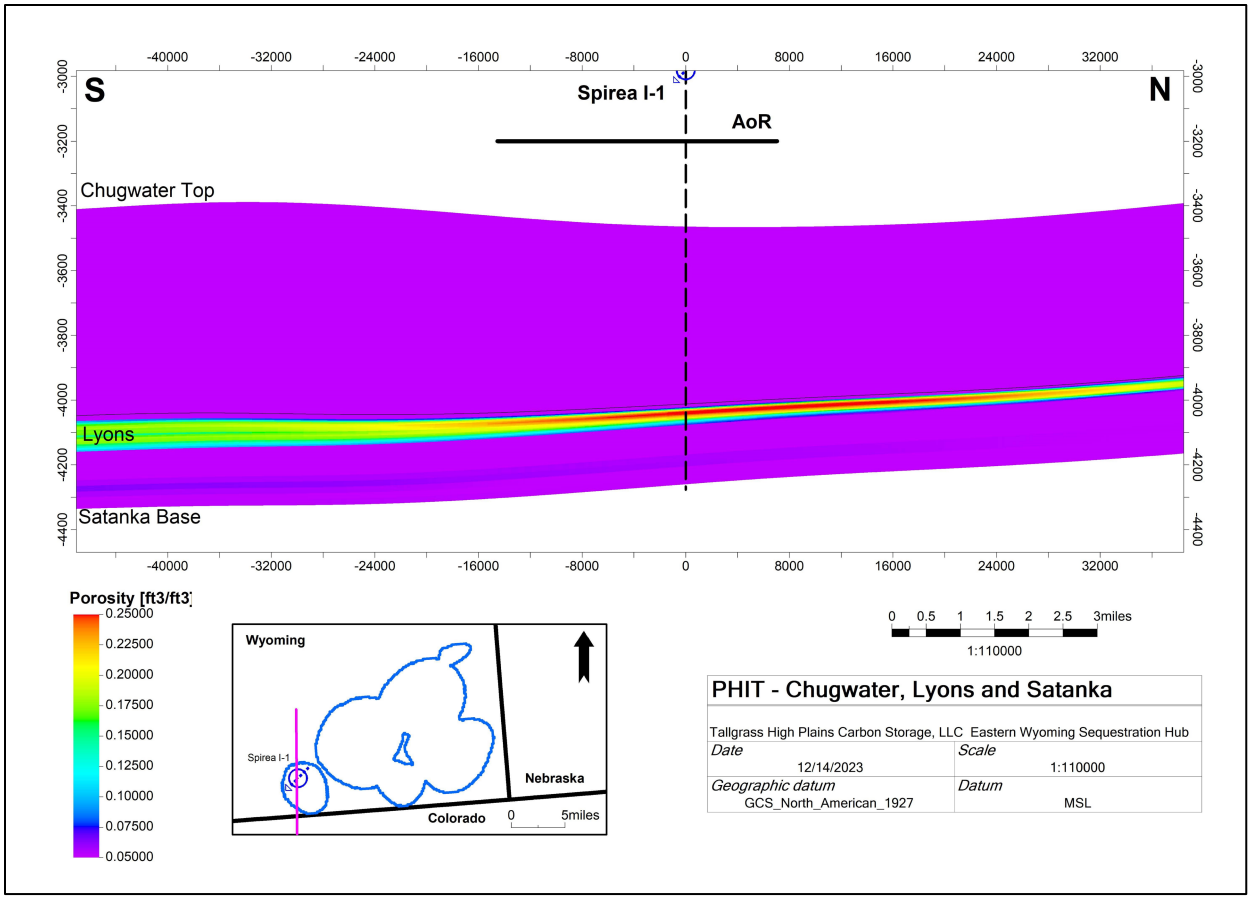



Figure 3.17—South to north cross section through the static geologic model at the location of the proposed Spirea I-1 well location showing distributed total porosity values in the Chugwater, Lyons, and Satanka formations.

Permeability was distributed in the geocellular static model using the porosity, permeability relationship shown in Figure 3.18. The correlation of porosity to permeability is defined by the best-fit trend line of the measured data taken from the Razor 26J-2633L (API: 051233749500), Marathon-Avalo 1-32 (API: 05123106700) and the Juniper M-1 (API: 490212954800). These values were then converted into brine permeability based on the Swanson $K_{air}/K_{brine}$ relationship (Swanson 1981). A more detailed discussion is provided in *Appendix C*.

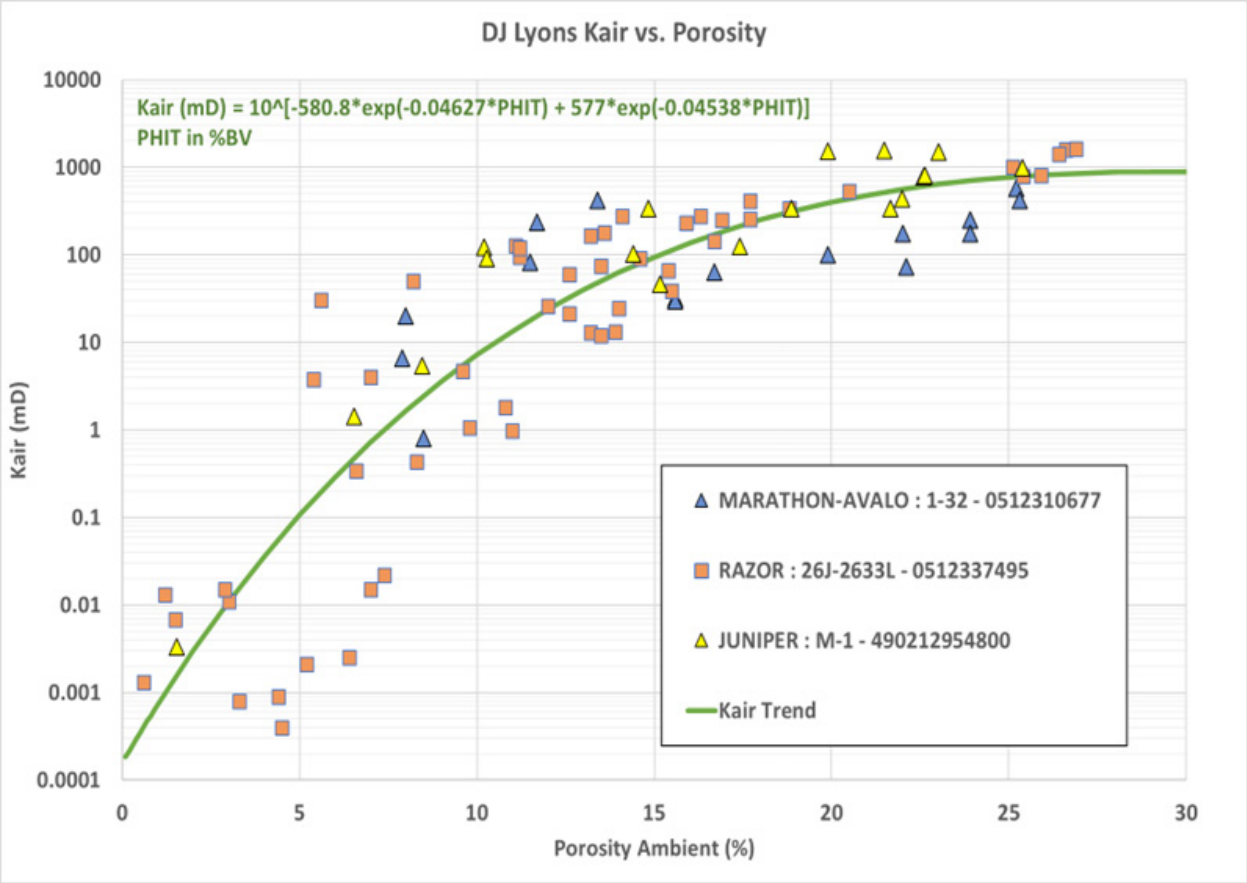


Figure 3.18—Porosity and permeability relationship.

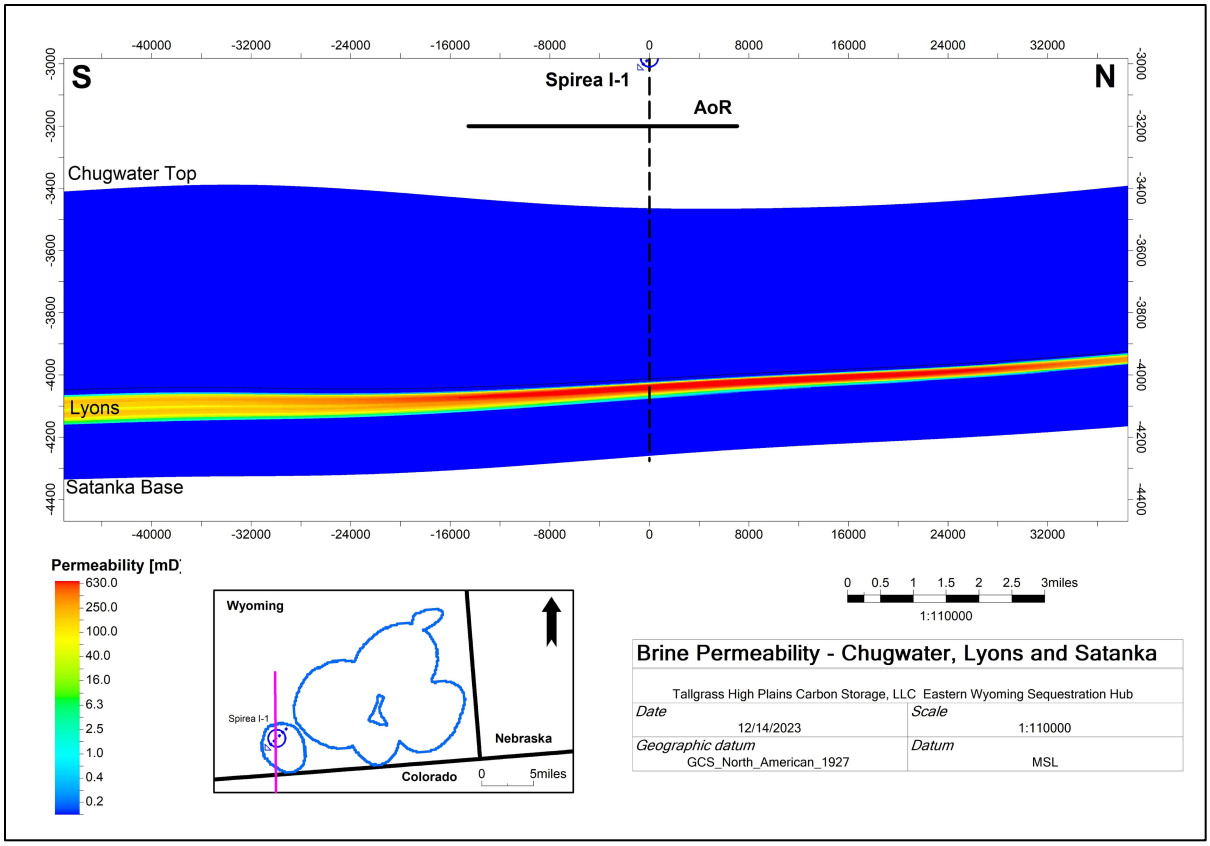



Figure 3.19—South to north cross section through the proposed injection well showing the distributed permeability property in the static geologic model.

### *3.4.2 Computational Model*

The static geologic model was used as an input for the dynamic simulation. A regional model was built to simulate the effect of the offset SWD wells and quantify the impact of injecting supercritical $CO_2$ in the Lyons Formation. The dynamic reservoir simulation model is comprised of 22 layers and approximately 14 million grid blocks. Six $CO_2$ injectors and eight SWDs (Table 3.7) were included in the model to evaluate the increase in reservoir pressure and $CO_2$ saturation.

Table 3.7—List of saltwater disposal wells included in the dynamic model.

| Well Name | UWI | Well Type | State | Latitude | Longitude |
|---|---|---|---|---|---|
| MARSHALL 31 SWD | 261052273500 | SWD | NE | 41.222543 | -103.559212 |
| NGL C9 SWD | 051234019400 | SWD | CO | 40.835985 | -104.159846 |
| NGL C9C SWD | 051234077100 | SWD | CO | 40.820625 | -104.161956 |
| RAZOR 21 SWD 1 | 051234077700 | SWD | CO | 40.823872 | -103.868780 |
| RAZOR 26J-2633L SWD | 051233749500 | SWD | CO | 40.808565 | -103.829466 |
| SIMBA 1-06 SWD | 051233103500 | SWD | CO | 40.955647 | -104.361223 |
| SWD C8A | 051233285800 | SWD | CO | 40.893947 | -104.335021 |
| WILDHORSE 16-13L SWD | 051233737400 | SWD | CO | 40.748580 | -103.989879 |

The dynamic simulation model was constructed as a pseudo-infinite acting reservoir that is fully saturated with brine. Based on 2D seismic interpretation and log information collected at the

Juniper M-1, the sands within the Lyons Formation have an average gross thickness of 55 ft. The Spirea I-1 well was completed in the model with all layers in the Lyons Formation open to flow. Table 3.8 summarizes the property values at initial conditions of the reservoir (discussed in more detail in *Appendix B*).

Table 3.8—Initial assumptions summary.

| Assumption | Value |
|---|---|
| Average Reservoir Permeability (mD) | 322 |
| Average Reservoir Porosity (%) | 17 |
| Net Thickness (ft) | 55 |
| Pore Gradient (psi/ft) | 0.34 |
| Frac Gradient (psi/ft) | 0.57 |
| Temperature Gradient (°F/100 ft) | 2.07 |
| Surface Temperature (°F) | 60 |
| $CO_2$ Phase | Supercritical |
| Salinity (mg/L) | 230,000 |

$CO_2$ will be injected in a supercritical phase at the surface. The model input parameters shown in Table 3.8 are shown on Figure 3.20 and demonstrate that at reservoir conditions sufficient temperature and pressure exist to support a supercritical phase.

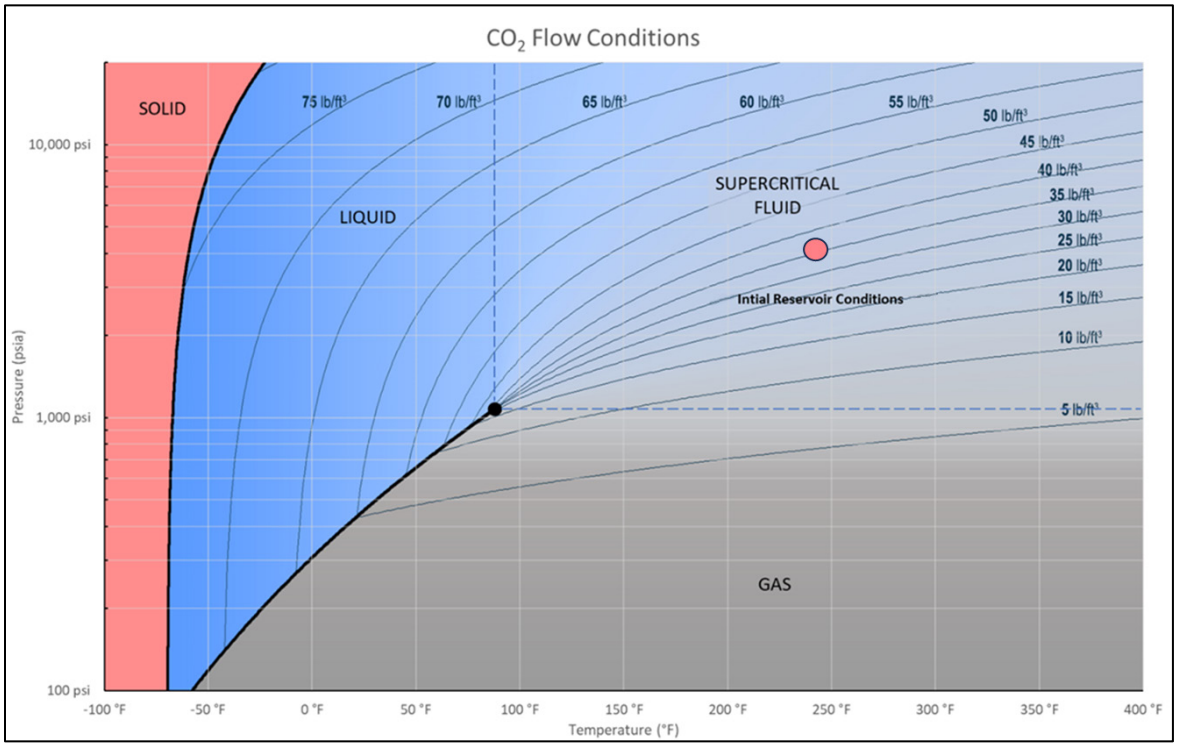



Figure 3.20—$CO_2$ phase diagram.

To account for the interference of two immiscible fluids in the pore space following the start of $CO_2$ injection, relative permeability curves are derived from the available literature including (Benson and Pini 2015). Two phase relative permeability curves for water are loaded into the

simulation model as a function of water saturation and water relative permeability. Supercritical $CO_2$ is loaded as a function of gas saturation, and gas relative permeability. Drainage relative permeability curves are used to model the injection period where non-wetting $CO_2$ displaces the wetting phase which is the formation brine. Similarly, imbibition relative permeability curves are used to model the process where wetting phase displaces the non-wetting phase, a process which typically takes place when injection stops. At the time of this writing, site-specific core data were collected at the Juniper M-1, but relative permeability testing was not complete. Relative permeability was derived from (Benson and Pini 2015). The published values provide a reasonable estimate based on the current understanding of the reservoir. Relative permeability curves shown in in Figure 3.21 are derived from the data presented in Figure 3.22 and used as inputs to the dynamic simulation model but require further calibration following data analysis. These estimated parameters will likely have an impact on future reevaluations of the model.

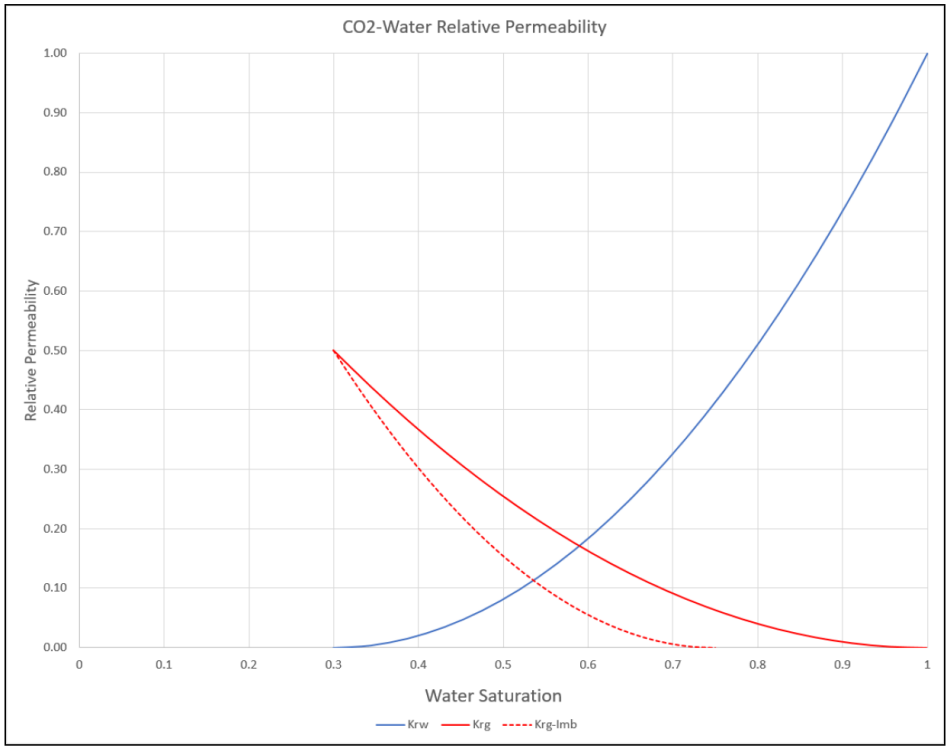


Figure 3.21—Supercritical $CO_2$-water relative permeability curves (Benson et al. 2015).

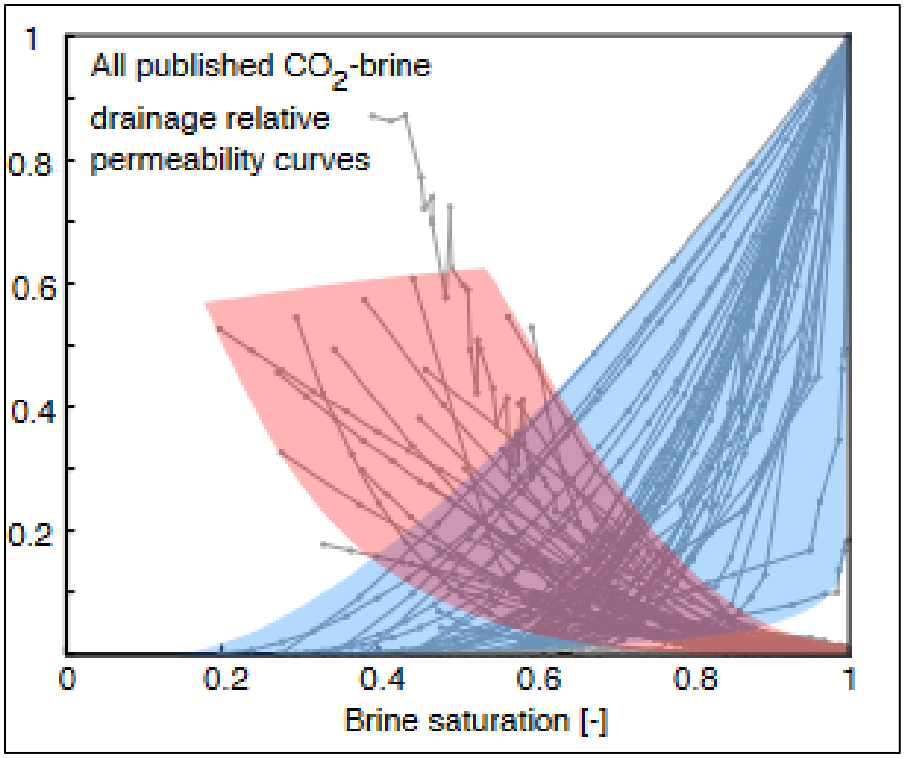


Figure 3.22—$CO_2$-water relative permeability curves (Benson et al. 2015).

The maximum extent of the plume at stabilization occurs in model year 2105, 50 years after the end of injection in the EWS Hub. The plume encompasses approximately 105,000 acres of Wyoming land, with the greatest length of the plume extending for approximately 22 miles (Figure 3.3).

An industry standard methodology was used to determine fracture gradient of a given rock. For this method, an isotropic model was assumed due to the lack of site-specific data. Once site-specific data has been gathered, updated inputs will be incorporated into an anisotropic model that will be used to account for the heterogeneity of the rock. Our best estimate of fracture gradient at this time is 0.57 psi/ft. In accordance with the Wyoming Department of Environmental Quality's (WYDEQ) Water Quality Rules, Chapter 13 (020-0011-13 Wyoming Code R**. §24.18(a)**), whereby injection operations must not exceed 90% of the fracture gradient, a maximum injection pressure gradient used in the dynamic simulation model was 0.51 psi/ft (Equation 3.1).

Equation 3.1—Maximum injection gradient calculation.

$$P_{Constraint} = 0.9 \times FG \ \frac{psi}{ft}$$

$$P_{Constraint} = 0.9 \times 0.57 \ \frac{psi}{ft}$$

$$P_{Constraint} = 0.51 \ \frac{psi}{ft}$$

The $CO_2$ injection rate for the EWS Hub was modeled with both a group maximum rate and per well maximum rate. The group rate was constrained to 5.1 MMT/year and a per-well maximum

rate of 1.5 MMT/year. As the offset wells to Spirea I-1 in the EWS Hub reach the end of injection, additional volume is then allocated in the model to the Spirea I-1. The maximum modeled bottom hole pressure reaches 4,509 psi which is 337 psi less than the constraint pressure of 4,846 psi. The constraint pressure was calculated as 90% of the fracture. Table 3.9 provides a summary of injection operations, and a more detailed explanation is included in *Appendix B*.

Table 3.9—Wellbore model outputs summary during injection.

| Wellbore Parameter | Value |
|---|---|
| Max Injection Rate (MT/yr) | 1,500,000 |
| Average Injection Rate (MT/day) | 1,656 |
| Max BHP (psi) | 4,509 |
| Average BHP (psi) | 4,210 |
| Max Wellhead Pressure (WHP) (psi) | 1,597 |
| Average WHP (psi) | 1,420 |

### *3.4.3 AoR Delineation*

To calculate the extent of the AoR, the maximum increase in the reservoir pressure resulting from the injection of supercritical $CO_2$ was evaluated at all points within the model domain, and compared to the critical pressure calculated in *Appendix B*. At no point in the model domain is there sufficient hydraulic potential to lift fluid from the injection zone into the Fox Hills (lowermost confirmed USDW). The AoR was there for delineated by the extent of the modeled $CO_2$ saturation evaluated at a 2% cutoff as shown in Figure 3.23.

Per WYDEQ Chapter 24 **§10(b)(xii)**, an additional one-mile radius was added to the plume. This radius provides an extra buffer for plume and pressure dissipation. Monitoring equipment, as discussed in *Section 5 – Testing and Monitoring Plan*, will detect deviations in plume size and shape. Any deviations will be evaluated, and the model updated accordingly.

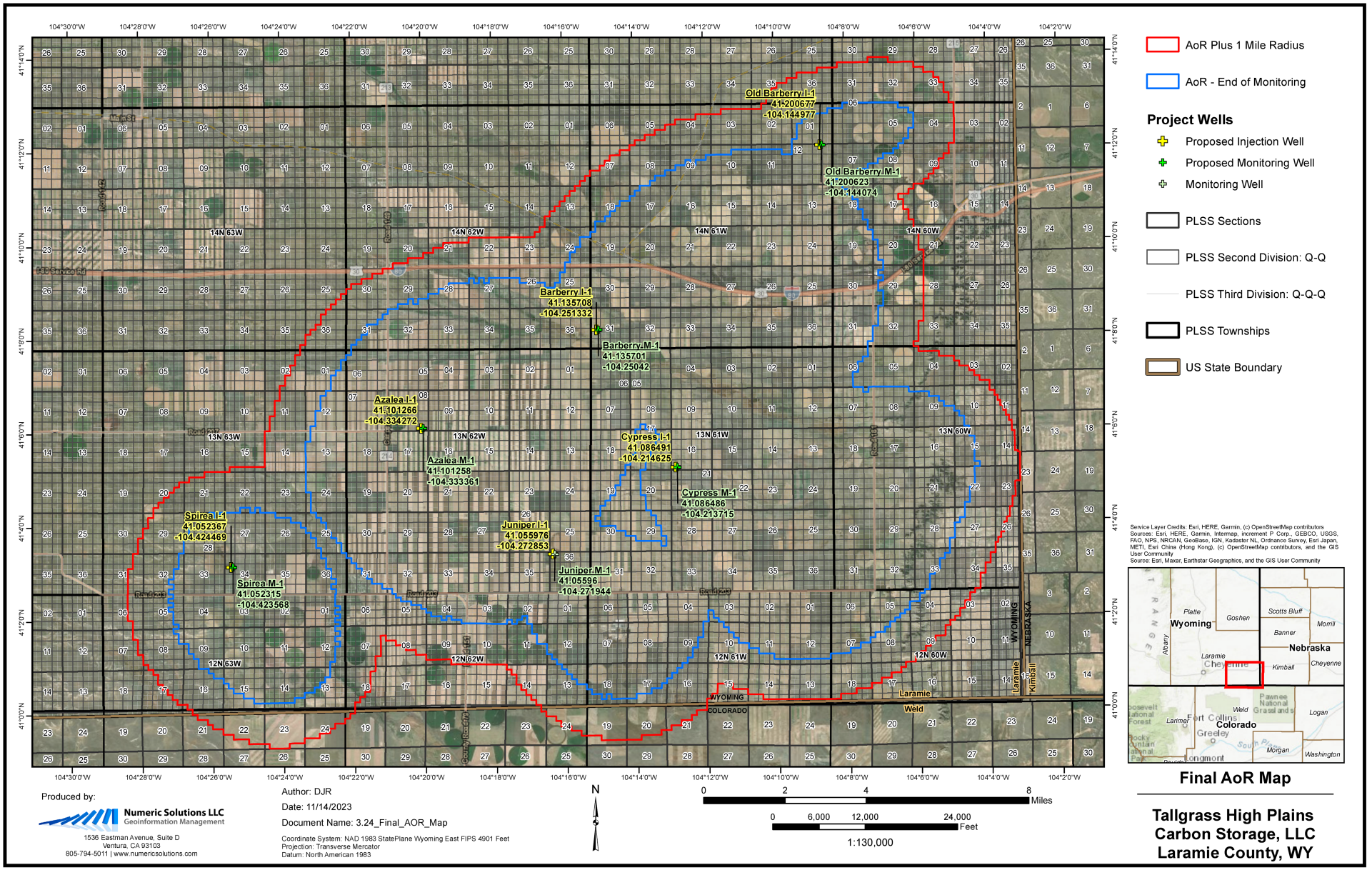



Figure 3.23—Map of the area of review including a one-mile boundary.

## 3.5 Area of Review and Corrective Action Plan

The AoR is understood as the area where a $CO_2$ sequestration project could cause endangerment to a USDW. This area, as explained in *Section 3.4.4*, is determined from plume and pressure front calculations and the resulting model. AoR reevaluations prior to the next scheduled reevaluation may also be warranted. Should this occur, the same steps as listed above will be undertaken to initiate reporting and corrective action as necessary. Examples of occurrences that could trigger a reevaluation of the AoR prior to the next schedules update include but are not limited to:

- Planned changes to maximum injection rate and/or duration that would extend the simulated AoR.
- Changes to the composition of the injectate to a mixture that extends the simulated AoR.
- New or re-interpreted site characterization data, such as core-derived petrophysical data, that extends the simulated AoR.
- New operations that are brought online within or near the plume extents that result in an increased extent of the AoR simulation.
- Loss of containment or loss of well integrity, as detected through monitoring systems in the form of water sampling and/or pressure/temperature changes.
- Identification of any new/previously unknown wells within the AoR that penetrate the confining zone.
- A seismicity incident, as detected by nearby USGS seismic stations, that results in such occurrences as changes to reservoir pressure or loss of containment.

In each case, the reservoir plume model will be re-run. If the plume increases in shape or extents, the AoR will be re-evaluated.

A total of 654 wells (597 water wells and 57 oil and gas wells) have been identified within the AoR. Of these, only three penetrate the upper confining zone. Two wells are shown in Table 3.10, with Juniper M-1 being discussed separately. Juniper M-1 was drilled by High Plains as a stratigraphic test well and was competed in the Lyons Sandstone to collect fluid samples. It was constructed with $CO_2$ resistant material across the injection zone. The well is currently open in the Lyons Formation, but it will be plugged back with $CO_2$ corrosion resistant cement before injection commences at the EWS Hub. Fritz 1 and UPRR Palm 1-21 were drilled and abandoned without running production casing (Table 3.10). UPRR Palm 1-21 contains adequate cement plugs across relevant formations and does not require corrective action (Table 3.11). Fritz 1 does not provide cement plugs $\leq$ 2,500 ft apart as per the current WOGCC abandonment regulations (Section 18, Form 4) and will need to have remedial work prior to $CO_2$ injection (Table 3.12).

Table 3.10—Identified for Corrective Action

| Well Name | Spud Date | Surface Casing o.d, in | Long String Casing o.d., in | Hole Direction | TD,ft | TVD, ft | Status | Plug Date | TWN | RNG | Sec | Qr-Qrt | Corrective Action Needed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 E.Fritz | 02/29/1953 | 10 3/4" | none | Vertical | 9,015 | 9,015 | DH | 5/7/1953 | 14N | 61 W 6 | 36 | C-SE, NE | Yes |
| UPRR-Palm 1-21 | 10/14/1981 | 9 5/8" | none | Vertical | 9,420 | 9,420 | DH | 11/3/1981 | 13N | 62 W 6 | 21 | SE, SW | No |

Table 3.11—Well evaluation for corrective action (UPRR Palm 1-21)

**Well Name: UPRR-Palm 1-21, API 4902120254**

| Cement Plugs | | | | Formation | | |
|---|---|---|---|---|---|---|
| Interval, ft | | Thickness, ft | Volume, sacks | Name | Estimated Top, ft | Cement Plug Remarks |
| - | 30 | 30 | 15 | Fox Hills | 1,023 | 9.0 ppg abandonment mud |
| 303 | 403 | 100 | 35 | Pierre (±B. USDW) | 1,233 | 9.0 ppg abandonment mud |
| 1,950 | 2,150 | 200 | 50 | Hygiene (Larimer) | 4,406 | 9.0 ppg abandonment mud |
| 4,780 | 4,880 | 100 | 35 | Shannon | 5,480 | 9.0 ppg abandonment mud |
| 6,780 | 6,880 | 100 | 35 | Niobrara | 7,138 | 9.0 ppg abandonment mud |
| 9,280 | 9,380 | 100 | 35 | Dakota | 8,316 | 9.0 ppg abandonment mud |
| | | | | Morrison | 8,535 | 9.0 ppg abandonment mud |
| | | | | Sundance | 8,694 | 9.0 ppg abandonment mud |
| | | | | Chugwater (T. UCZ) | 8,781 | 9.0 ppg abandonment mud |
| | | | | Goose Egg/Lykins | 9,026 | 9.0 ppg abandonment mud |
| | | | | Freezout_Sh | 9,036 | 9.0 ppg abandonment mud |
| | | | | Minnektahta | 9,069 | 9.0 ppg abandonment mud |
| | | | | Opeche_sh | 9,186 | 9.0 ppg abandonment mud |
| | | | | Flowerpot_sh | 9,246 | 9.0 ppg abandonment mud |
| | | | | Flowerpot_anh | 9,260 | 9.0 ppg abandonment mud |
| | | | | Lyons Sand | 9,299 | 35 sx plug set across Lyons |
| | | | | Satanka | 9,365 | 9.0 ppg abandonment mud |

**Corrective Action: None**

Table 3.12—Well Evaluation for corrective action (Fritz 1).

| Well Name: 1 E.Fritz, API 4902105033 | | | | | | |
|---|---|---|---|---|---|---|
| Cement Plugs | | | | Formation | | Cement Plug Remarks |
| Interval, ft | | Thickness, ft | Volume, sacks | Name | Estimated Top, ft (MD) | |
| - | 30 | 30 | 15 | Fox Hills (lowermost USDW) | 681 | 9.5 ppg abandonment mud |
| 300 | 350 | 50 | 25 | Pierre Sh. (bUSDW) | 878 | 9.5 ppg abandonment mud |
| 7,520 | 7,625 | 105 | 47 | "J" Sand | 7,520 | 47 sx plug set across J Sand |
| 8,670 | 8,775 | 105 | 45 | Dakota Fm. | 7,767 | 9.5 ppg abandonment mud |
| | | | | Morrison Fm | 7,948 | 9.5 ppg abandonment mud |
| | | | | Sundance Fm. | 8,116 | 9.5 ppg abandonment mud |
| | | | | Chugwater Fm.(UCZ) | 8,198 | 9.5 ppg abandonment mud |
| | | | | Goose Egg Fm. (UCZ) | 8,411 | 9.5 ppg abandonment mud |
| | | | | Lyons Sand | 8,690 | 45 sx plug set across Lyons |
| | | | | Satanka Sh. (LCZ) | 8,775 | 9.5 ppg abandonment mud |
| | | | | **Corrective Action: An attempt will be made to re-enter the wellbore to set plugs as per current regulatory requirements and isolate the USDW with cement** | | |

The Fritz 1 well does not provide cement plugs ≤ 2,500 ft apart as per the current WOGCC abandonment regulations (Section 18, Form 4) and will need to have corrective action attempted. Well Fritz 1 is in the AoR of the proposed injection site and will need to have remedial work prior to $CO_2$ injection operations.

The procedures described are subject to modification during execution as necessary to ensure a plugging operation that protects worker safety and is effective to protect USDWs; any significant modifications due to unforeseen circumstances will be described in the plugging report. Completed plugging forms, associated charts, and all laboratory information will be provided to the regulatory agency as required by permit. The plugging report shall be certified as accurate by High Plains and the plugging contractor and shall be submitted within 60 days after plugging is completed.

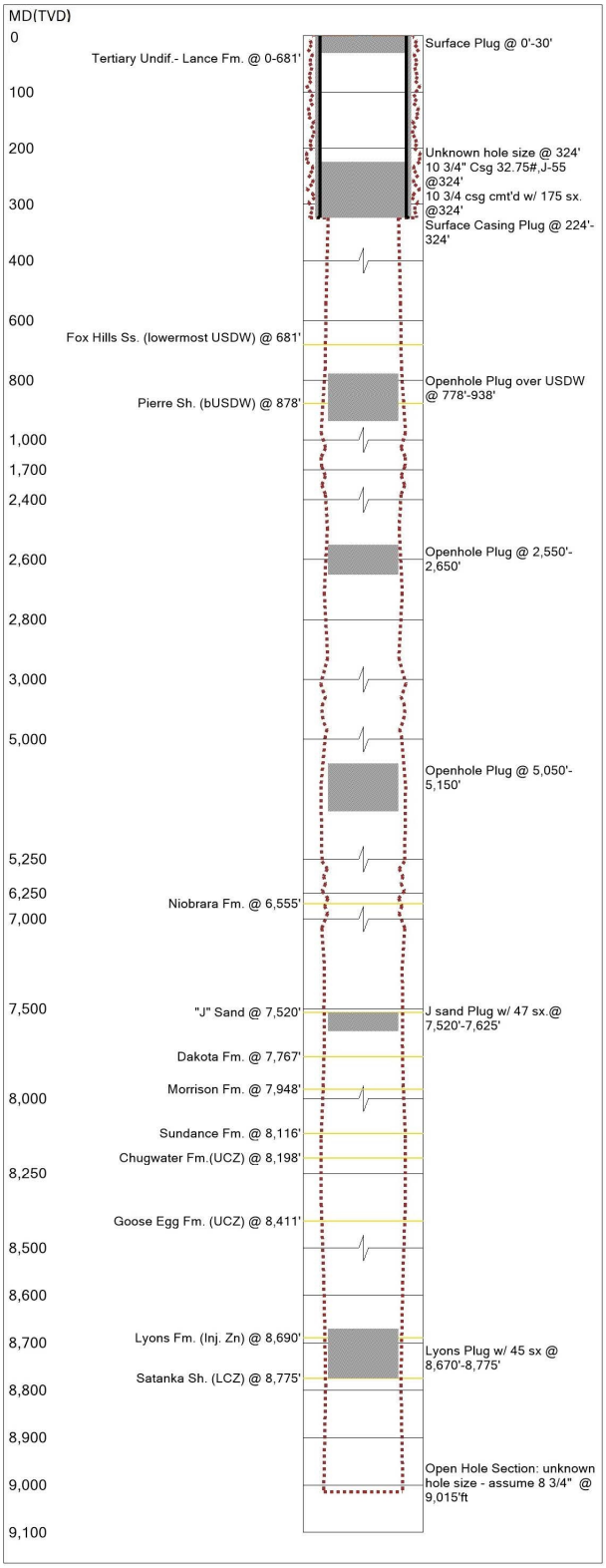
The procedure for remedial plugging and abandonment of the Fritz 1 is described; depth reference is from ground level (GL) and depth is measured depth (MD) unless otherwise noted:

- Prepare location for service rig.
- Have surveyors locate well location.
- MIRU excavator and locate old casing stub.
- Hot tap well cap/plate and ensure no residual gas underneath.

- Cut and remove well cap, install casing bowl.
- Move in workover rig and rig up.
- Install blowout preventer equipment and test to rated pressure.
- Move in workover rig and rig up. Notify by phone WDEQ a minimum of 24 hours prior to moving in rig.
- Pickup workstring with 8-3/4 in. drill bit and drill out existing surface cement plug and bottom-most plug to bottom of surface casing.
- RIH to 5,150 ft and circulate hole clean with 9.5 ppg/70 vis abandonment mud.
- Pull out of hole, remove drill bit.
- RIH open-ended and prepare to set cement plugs.
- Set a minimum of 100-feet (8 bbls) balanced, Class G, cement plug from 5,050–5,150 ft.
- Pull up and reverse circulate cement out of string.
- WOC 8 hrs and tag.
- Pull up to 2,650 ft.
- Set 100-feet (8bbls) balanced, Class G, cement plug from 2,550–2,650 ft.
- Pull up and reverse circulate cement out of string.
- WOC 8hrs and tag.
- Pull up to 938 ft.
- Set 160-feet (12 bbls) balanced, Class G, cement plug from 778–938 ft to cover the lowermost confirmed USDW at 878 ft.
- Pull up and reverse circulate cement out of string.
- WOC 8 hrs and tag.
- Pull up to surface casing shoe at 324 ft.
- Set 100-feet (10 bbls) balanced, Class G, cement plug from 224–324 ft.
- Pull up and reverse circulate cement out of string
- WOC 8 hrs and tag.
- Set 30-feet (3 bbls) balanced, Class G, cement plug from surface to 30 ft
- WOC, cut casing.
- Weld steel plate at top of well with name and identification of well permanently in the plate.

Rig down workover rig and move out.

A wellbore diagram of the Fritz 1 after the proposed corrective action is provided in Figure 3.24.




**Last Updated:** 10/12/2023 04:36 PM

| Field Name | Lease Name | Well No. |
|---|---|---|
| Tracy | E Fritz | 1 |

| County | State | API No. |
|---|---|---|
| Laramie | WY | 49-021-05033-0000 |

| GL (ft) | KB (ft) | Section | Township/Block | Range/Survey |
|---|---|---|---|---|
| 5,189.0 | 10.0 | 36 | 14N | 61W |

| Operator | Well Type | Well Status |
|---|---|---|
| GINTHER, WARREN & GINTHER | Dry hole | Proposed Corrective Action |

| Latitude | Longitude |
|---|---|
| 41.1377890 | -104.1418190 |

| Prop Num | Spud Date | Comp. Date | Plug Date |
|---|---|---|---|
| | 2/28/1950 | | 5/7/2003 |

**Hole Summary**

| Date | Diam. (in) | Top (MD ft) | Bottom (MD ft) | Memo |
|---|---|---|---|---|
| | 12.000 | 0 | 324 | |
| | 8.750 | 324 | 9,015 | |

**Tubular Summary**

| Date | Description | OD (in) | Wt (lb/ft) | Grade | Top (MD ft) | Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|---|
| | Surface Casing | 10.750 | 32.75 | J-55 | 0 | 324 | C |

**Casing Cement Summary**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 175 | 10.750 | 0 | 324 | Cmt to surface | C |

**Cement Plug Summary**

| C | Date | No. Sx | OD (in) | Top (MD ft) | Bottom (MD ft) | Memo | RL |
|---|---|---|---|---|---|---|---|
| | | | 10.750 | 0 | 30 | | C |
| | | | 10.750 | 224 | 324 | | C |
| | | | 8.750 | 778 | 938 | bUSDW @ 878' | C |
| | | | 8.750 | 2,550 | 2,650 | | C |
| | | | 8.750 | 5,050 | 5,150 | | C |
| | | 47 | 8.750 | 7,520 | 7,625 | "J" sand @ 7,520' | C |
| | | 45 | 8.750 | 8,670 | 8,775 | Lyons formation 8690-8774' | C |

Figure 3.24—Proposed wellbore diagram after remedial work for the Fritz 1.

High Plains plans to drill the following well (other than the proposed injection wells) within the AoR, which will penetrate the upper confining zone, prior to the start of injection:

- Cypress M-2 (49-021-29598)

### 3.6 Reevaluation of AoR and Corrective Action Plan

High Plains will regularly reevaluate the AoR and corrective action plan, per the requirements of WYDEQ Chapter 24 §13(c), at least every two years during the operational life of the EWS Hub and every five years during the post-injection site care period (until site closure)—or when monitoring and operational conditions warrant a reevaluation prior to the next scheduled reevaluation.

AoR and corrective action reevaluations during regularly scheduled events include but are not limited by the following:

- Review collected monitoring data and compare to the existing computational model results. Monitoring and operational data from the injection and monitoring wells will be assessed to determine whether the predicted $CO_2$ plume migration is consistent with actual data. This workflow includes reviews of:
    - Groundwater chemistry monitoring data taken in the monitoring wells to verify that $CO_2$ or non-native brine has/has not invaded and endangered any USDWs.
    - Available data on the position of the $CO_2$ plume and pressure front, including pressure and temperature monitoring data and pulsed neutron log (PNL) saturation and seismic survey data. Activities will include:
        - Reviewing downhole reservoir pressure and temperature data collected from the injection wells using a combination of surface and downhole pressure gauges.
        - Operational changes such as injection rates and pressures, to verify that these data are consistent with the inputs used in the most recent modeling simulation.

If the new monitoring and operating data reviewed is consistent with the most recent modeling assumptions and is not expected to materially influence the modeled extent of plume and pressure front movement, no reevaluation of the AoR will be undertaken. A report will be generated to include the data and results demonstrating that no changes are necessary. If material changes have occurred, then the conceptual model will be updated with the new data and a report will be generated and sent to WYDEQ. This report will include comparisons between the previous simulation and the updated version, details of potential corrective action and a current status of the corrective action. The report will be submitted to WDEQ within one year of the reevaluation. The AoR and Corrective Action Plan will then be updated to reflect the revised AoR, along with other related project plans, as needed.

## 3.7 References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# 4 SUPPORTING PERMIT PLANS

## 4.1 Emergency and Remedial Response Plan

### *4.1.1 Background*

The following Emergency and Remedial Response Plan (ERRP) was prepared to meet the requirements of WYDEQ Chapter 24 **§25** to identify, prevent, and respond to an emergency event at the EWS Hub. The locations of the injection well and the monitoring wells are identified in Table 4.1. This plan incorporates the Testing and Monitoring plan described in *Section 4.3* to verify that the EWS Hub is operating as permitted and not endangering a USDW.

A list of possible emergency events has been generated and provided further in Table 4.2. Table 4.3 includes the response actions to be taken, when an emergency event has been detected related to the movement of the injectate or formation fluids that may endanger a USDW—or threaten human health, safety, and/or the environment. This plan will remain in place during the construction, operation, closure, and post-closure periods. The procedures in this plan outline the response to coordinate among the emergency response team, local resources, surface owners, mineral claimants, mineral owners, lessees, owners of record with subsurface interests, and governmental authorities. The plan's objectives are to minimize the impact of the potential for loss of life and maximize the protection of the environment, the surrounding community, and company property.

Table 4.1—Well names and location information.

| Proposed Facility Location | | | | | | |
|---|---|---|---|---|---|---|
| **County** | **Latitude*** | **Longitude*** | **Section** | **Township** | **Range** | **Qrt-Qrt** |
| Laramie | 41.052367 | -104.424469 | 34 | 13N | 63W | SW/NW |
| Facility Address: TBD | | | | | | |
| **Well Name** | **Latitude*** | **Longitude*** | **Section** | **Township** | **Range** | **Qrt-Qrt** |
| **Proposed Injection Well Locations** | | | | | | |
| Juniper I-1 | 41.055976 | -104.272853 | 36 | 13N | 62W | NW/NW |
| Azalea I-1 | 41.101266 | -104.334272 | 8 | 13N | 62W | SE/SE |
| Cypress I-1 | 41.086491 | -104.214625 | 16 | 13N | 61W | SW/SW |
| Barberry I-1 | 41.135708 | -104.251332 | 31 | 14N | 61W | NW/SW |
| Old Barberry I-1 | 41.200677 | -104.144977 | 12 | 14N | 61W | NW/NE |
| Spirea I-1 | 41.052367 | -104.424469 | 34 | 13N | 63W | SW/NW |
| **Deep Monitoring Well Locations** | | | | | | |
| Juniper M-1 | 41.05596 | -104.271944 | 36 | 13N | 62W | NW/NW |
| Azalea M-1 | 41.101258 | -104.333361 | 8 | 13N | 62W | SE/SE |
| Cypress M-1 | 41.086486 | -104.213715 | 16 | 13N | 61W | SW/SW |
| Barberry M-1 | 41.135701 | -104.25042 | 31 | 14N | 61W | NW/SW |
| Old Barberry M-1 | 41.200623 | -104.144074 | 12 | 14N | 61W | NW/NE |
| Spirea M-1 | 41.052315 | -104.423568 | 34 | 13N | 63W | SW/NW |

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### *4.1.2 Local Resources and Infrastructure*

The EWS Hub is in the southeast corner of Wyoming, approximately 14 miles southwest of Pine Bluffs. The Project Area and well locations were selected to minimize the potential impact on the surrounding landowners, farming areas, nearby communities, livestock, and wildlife. The infrastructure which an event could impact, including residences, farmland, oil and gas wells, water wells, roads, and pipelines, is shown in Figure 4.1. No tribal lands are located near the EWS Hub. The defined AoR includes 360 homes and residences, and 804 agricultural/other structures. Currently, the EWS Hub plans do not include large-structure construction, such as processing facilities, compression equipment, etc. To reduce environmental or safety impacts, assistance from local resources will be activated based on the type and severity of an event.

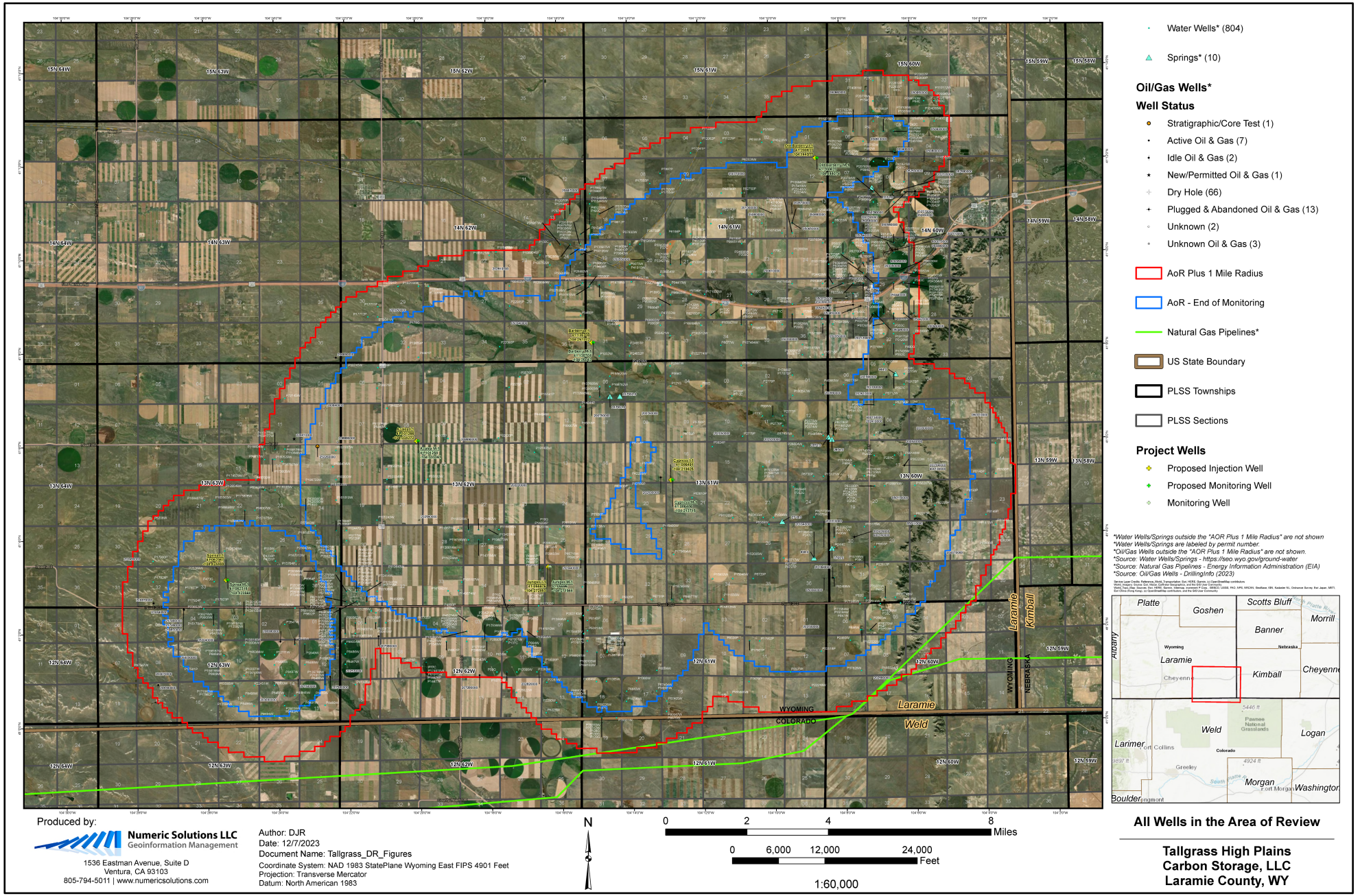



Figure 4.1—Map of local resources and infrastructure.

### *4.1.3 Identification of Potential Emergency Events*

An emergency event is defined as an event which may endanger a USDW or may threaten human health, safety, and/or the environment during the construction, operation, closure, and post-closure periods—due to the movement of the injectate, formation, or other fluids. Other events include the risk of accidental release of $CO_2$ into the atmosphere. Potential emergency events and the methods that will be used to identify such an event are included in Table 4.2.

Table 4.2—Potential EWS Hub emergency events and their detection.

| Potential Emergency Events | Detection of Emergency Event |
|---|---|
| Well control event while drilling or completing the well with the loss of containments | • Sudden increase in drilling rate<br>• Increase in flow rate at the surface<br>• Changes in pump pressure<br>• Reduction in drill pipe weight<br>• Increase in gas, oil, or water-cut mud |
| Movement of brine between formations during drilling | • Indication of lost circulation |
| Presence of hydrogen sulfide ($H_2S$) while drilling or completing the well | • $H_2S$ monitors located on the well site |
| Loss of mechanical integrity (flowlines, injection, monitoring wells, disposal well) | • Deviation of expected distributed temperature sensing (DTS) and distributed acoustic sensing (DAS) detects leaks in $CO_2$ flowline, injection well, and monitoring wells.<br>• Wellhead pressure monitoring measurement exceeds maximum injection wellhead pressure.<br>• Annular pressure monitoring exceeds expected pressure. |
| Loss of containment (LOC): vertical migration of $CO_2$/brines via injection wells, monitor wells, plugging and abandonment (P&A) wells, and undocumented wells | • Sampling and analysis indicate deviations of baseline values of groundwater wells, and monitoring wells.<br>• Deviation of expected DTS/DAS measurements<br>• $CO_2$ detectors at injection facilities indicate increased levels of $CO_2$ release. |
| LOC: lateral migration of $CO_2$ outside of defined AoR | • Sampling and analysis indicate deviations of baseline values of groundwater wells, monitoring wells.<br>• Indications of lateral migration on time-lapse 2D seismic survey |
| LOC: vertical migration due to failure in the confining zones, faults, and fractures | • Changes in downhole pressure and temperature, $CO_2$ measurements, and water chemistry analysis |

| Potential Emergency Events | Detection of Emergency Event |
|---|---|
| External impact on flowlines, wells, and infrastructure | • Indication of $CO_2$ leak from detection systems in place |
| Monitoring equipment failure or malfunction | • Monitoring systems will alert site personnel if one or more portions of the system fail. Site personnel will also be reviewing data for anomalies. |
| Induced seismicity | • Seismic monitoring station |
| Seismic event | • Seismic monitoring station |
| Other natural disasters | • Tornados and severe storms, including lightning strikes, are additional risks that create the potential for the release of $CO_2$ due to injection well and EWS Hub damage, and that may disrupt surface and subsurface operations.<br>• Monitoring systems will alert personnel to changes in operating parameters that may indicate the impact of such an event. |

### *4.1.4 Emergency Response Actions*

If monitoring data or information indicates that injection operations may pose a threat or endangerment to a USDW, human health, safety, and/or the environment, the procedures to be performed are to:

- Immediately cease all injections;
- Take all steps reasonably necessary to identify and characterize any release;
- Verbally notify the WYDEQ Administrator within 24 hours of discovering the condition; and
- Provide a written report to the Administrator within five days of discovering the condition. The written report will contain the following:
    - A description of the noncompliance, malfunction, or excursion and its cause;
    - The period of noncompliance, including dates and times, and if the noncompliance has not been controlled, the anticipated time it is expected to continue; and
    - Steps taken or planned to reduce, eliminate, and prevent the event's reoccurrence.

If a noncompliance condition or requirement under WYDEQ Chapter 24—or any malfunction of the injection system—occurs that may cause fluid migration into or between USDWs, High Plains shall:

- Orally notify the Administrator within 24 hours of discovery;
- Provide a written report to the Administrator within five days of discovery that contains the following:
    - A description of the noncompliance, malfunction, or excursion and its cause;

- The period of noncompliance, malfunction, or excursion, including exact dates and times; or if the noncompliance, malfunction, or excursion has not been controlled, the anticipated time it is expected to continue; and
- Steps taken or planned to reduce, eliminate, and prevent the reoccurrence of the noncompliance, malfunction, or excursion.

If an excursion is discovered, written notice will be provided to all surface owners, mineral claimants, mineral owners, lessees, and other owners of record of subsurface interests within 30 days of discovering the excursion, and High Plains will implement the ERRP approved by the Administrator.

Table 4.34.3 lists the actions needed to determine the cause of an event and planned emergency responses.

Table 4.3—Actions necessary to determine cause of events and appropriate emergency response.

| Emergency Action | Determine Cause and Emergency Response |
|---|---|
| Failure of the $CO_2$ flow line from the capture system to the injection wellhead | • The DAS/DTS system at the EWS Hub will trigger an alarm upon any detected release of $CO_2$ and will automatically shut in the flow line.<br>• In the event of a significant release of $CO_2$, personnel will be evacuated until $CO_2$ monitors indicate the $CO_2$ has been sufficiently dispersed to safe levels.<br>• The pipeline will be inspected to determine the cause of failure, and the damaged flowline will be repaired or replaced. |
| Well control event while drilling or completing the well with the loss of containments | • Initiate well control procedures, including closing blowout prevention equipment and/or using appropriate drilling fluids and flow restrictions.<br>• Determine the cause of the event and remediate as necessary.<br>• Contact the Administrator within 24 hours of the emergency event. |
| Integrity failure of injection or monitoring well | • Pressures and temperatures in the injection well and monitoring wells will be monitored for indication of integrity failure and determination of the cause and extent of the failure.<br>• If wellhead pressure exceeds the maximum allowed surface pressure or the annulus pressure indicates a loss of integrity, the well will automatically be shut in.<br>• Notify the Administrator within 24 hours of an event that triggers an automatic shutdown.<br>• Once the cause of failure is identified, determine the extent of any surface and subsurface impacts, and perform remediation as needed in coordination with the Administrator. |

| Emergency Action | Determine Cause and Emergency Response |
|---|---|
| | • Notify the Administrator when injection can be expected to resume. |
| Failure of injection well monitoring equipment | • Pressure and temperature gauges will be continuously monitored, and the well's Supervisory Control and Data Acquisition (SCADA) system will alert personnel of any monitoring equipment failure.<br>• Notify the Administrator within 24 hours of an event.<br>• Once the cause of failure is identified, repair or replace the equipment in coordination with the Administrator. Remediate any contamination resulting from the event. |
| Leakage of $CO_2$ from the storage reservoir | • Analysis of data from the monitoring wells plus the proposed groundwater monitoring systems, per the Testing and Monitoring Plan, will indicate the release of $CO_2$ out of the injection interval.<br>• If measurements indicate the risk of $CO_2$ leakage, injection operations will cease until the root cause is identified.<br>• If the indicator parameters are identified, High Plains will develop a work plan to implement additional monitoring stations, as needed, and develop a remediation plan in coordination with the Administrator.<br>• If samples from the USDW indicate parameters outside of drinking water standards, High Plains will arrange for an alternate potable water supply until the USDW is remediated.<br>• If $CO_2$ is released to the surface in excess of predetermined parameters, an evacuation plan will be initiated. |
| Induced seismic event | • Identify the location, depth, and magnitude of the event.<br>• If a seismic event occurs within the AoR of the injection well, of a magnitude greater than 3.0, review the pressure and volume injection history to determine if there is a correlation with the injection activities. Confirm that the well has maintained mechanical integrity and whether a loss of $CO_2$ containment has occurred.<br>• Remediate as necessary in coordination with the Administrator. |
| Natural disaster | • Preparations will be made as appropriate before the forecasted event, when possible. This would include the shutdown of the EWS Hub if necessary.<br>• Well pressures and temperatures will be continuously monitored to detect any release of $CO_2$ caused by a natural disaster event. |

| Emergency Action | Determine Cause and Emergency Response |
|---|---|
| | • If inspections or monitoring measurements indicate damage to the injection system, injection operations will cease immediately.<br>• Remediate as necessary in coordination with the Administrator. |

### *4.1.5 Response Personnel/Equipment and Training*

High Plains will use an Incident Command System (ICS) response structure (Figure 4.2) when an emergency event has been detected. This structure identifies the individuals designated as team members and indicates the responsibilities required (Figure 4.2).

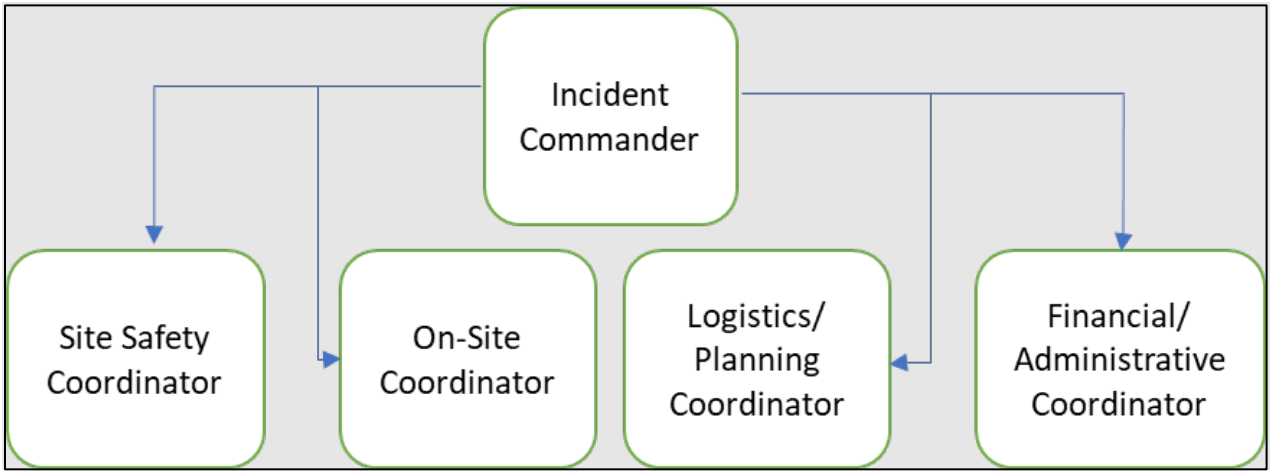



Figure 4.2—Incident command system response structure.

The **Incident Commander** is responsible for managing the emergency event and will coordinate emergency response activities. The commander must be fully briefed and have a written delegation of authority. Initially, assigning tactical resources and overseeing operations will be under the commander's direct supervision.

The Incident Commander is responsible for ensuring incident safety, providing information services to internal and external stakeholders, and establishing and maintaining liaison with other agencies participating in the incident. These responsibilities include the following:

- Meet with the operations chief for a briefing on the situation and current activities of on-site personnel.
- Work on-scene with state and federal officials in a support and advisory role.
- Prepare for post-emergency operations to make repairs and return the EWS Hub to service.
- Conduct containment and cleanup operations to minimize personnel and community exposure.
- Communicate with the media.

The **Site Safety Coordinator** ensures site, public, and employee safety; establishes the site safety plan; coordinates the environmental response; maintains contact with the area/region Environmental, Health, and Safety (EHS) Project Manager and other EHS personnel as required; and maintains contact with local, state, and federal emergency response organizations or other agencies as necessary.

The **On-Site Coordinator** handles on-site activities.

The **Logistics/Planning Coordinator** obtains the necessary response equipment, materials, contractors, other company personnel, etc.

The **Financial/Administrative Coordinator** arranges for humanitarian assistance, lodging, meals, etc., and manages purchase orders, contracts, etc.

Equipment

The type and severity of an emergency event will determine the equipment needed for the event response. Most event responses, such as stopping injections, well shut-in, etc., will not require special equipment. High Plains will provide any special equipment that might be needed.

Training

All EWS Hub personnel will undergo Hazardous Waste Operations and Emergency Response (HAZWOPER) training per Occupational Safety and Health Administration (OSHA) regulations. Training will cover the contents of the EWS Hub ERP, roles and responsibilities of the Emergency Response Team (i.e., ICS), and employee roles and responsibilities during emergency events, alarms, evacuation procedures, and drills.

High Plains will coordinate with local and county personnel to discuss the ERP and coordinate response actions, including annual drills.

### *4.1.6 Emergency Communications Plan*

Before initiating injection operations, High Plains will provide a written summary of this ERRP to the landowners adjacent to the EWS Hub. This summary will include information about the nature of the $CO_2$ injection operations, an operator emergency-contact list, potential risks, and responses. Additionally, High Plains will maintain an emergency contact list throughout the project's life. If an emergency event occurs, the Site Safety Coordinator will ensure that the correct personnel are contacted. High Plains' designated personnel will handle all communication with the public.

The EWS Hub will rely on pre-designated radio frequencies and telecommunications numbers to manage communications effectively.

### *4.1.7 Emergency and Remedial Response Plan Review and Updates*

This ERRP will be reviewed and updated in accordance with the schedule:

- Every two years during injection operations and every five years post-injection, in coordination with the AoR review
- Following any significant changes to the EWS Hub, such as adding injection or monitoring wells
- As required by the Administrator

## 4.2 Financial Assurance Demonstration Plan

This Financial Assurance Demonstration Plan (FADP) was developed to meet the requirements of WYDEQ Chapter 24 **§26**. High Plains will maintain financial responsibility for all applicable phases of this project, including:

- Permitting/characterization;
- Testing and monitoring (pursuant to Chapter 24 **§20**);
- Operations, including injection and well-plugging (pursuant to Chapter 24 **§18** and **§23**);
- Post-injection site care; and
- Emergency and remedial response (pursuant to Chapter 24 **§25**).

The estimation of required coverage is for the six injection wells and six monitoring wells listed in Table 4.4.

Table 4.4—Well names and location information for the wells included in the financial assurance cost estimation.

| **Project Wells** | |
|---|---|
| **Proposed Injection Wells** | **Proposed Deep Monitoring Wells** |
| Juniper I-1 | Juniper M-1 |
| Azalea I-1 | Azalea M-1 |
| Cypress I-1 | Cypress M-1 |
| Barberry I-1 | Barberry M-1 |
| Old Barberry I-1 | Old Barberry M-1 |
| Spirea I-1 | Spirea M-1 |

The estimates provided are based on recent costs from similar injection operations and the corrective actions planned in *Section* 3.5. These costs will be updated annually to account for inflation costs and project-related changes.

### *4.2.1 Cost Estimation*

A financial assurance cost estimate, based on current dollars, provided in Table 4.5, have been estimated for the following:

- Performing corrective action for all wells in the AoR that require it (as identified and approved by the Administrator)
- Plugging the injection wells

- Post-injection site care (including plume stabilization, monitoring, measurement, verification, corrective action, and other actions needed, to ensure that USDWs are not endangered from the time of well-plugging until site closure is certified by the Administrator and above ground-reclamation is completed) and site closure
- Testing and monitoring activities
- Emergency and remedial response

Table 4.5—Summary of financial assurance cost estimations.

| Activity Estimated Total Cost | |
|---|---|
| Corrective Action on Wells in the AoR | $565,000 |
| Plugging of Injection Wells (6 wells) | $3,582,000 |
| Post-Injection Site Care and Facility Closure | $20,218,000 |
| Emergency and Remedial Response (including endangerment to USDWs) | |
| *Barberry I-1, Old Barberry I-1, Azalea I-1, Cypress I-1, Juniper I-1* | $9,376,550 |
| *Spirea I-1* | $5,248,291 |
| **Total** | **$38,989,841** |

#### *4.2.1.1 Corrective Action*

Two wells within the AoR require corrective action. The Fritz 1 and Juniper M-1 will need to be remediated. The remediation costs included in Table 4.6. Table 4.6 are for remediations described in *Section* 3.5.

Table 4.6—Financial assurance cost estimations for corrective action within the area of review.

| Corrective Action Cost Estimate | |
|---|---|
| Juniper M-1 Plugback | $ 250,000 |
| E. Fritz 1 Remediation | $ 315,000 |
| **Subtotal** | **$ 565,000** |

#### *4.2.1.2 Injection Well Plugging*

The cost estimates for the plugging of the six injection wells listed in Proposed Injection Wells Section of Table 4.4 are estimated to cost $597,000 per well. The costs for this estimate are broken down in Table 4.7. A detailed plugging procedure is included for the Spirea I-1 in Section 4.5.1.

Table 4.7—Financial assurance cost estimations for injection well plugging.

| Injection Well P&A Cost Estimate | |
|---|---|
| Workover Rig | $ 100,000 |
| Rental Tools | $ 15,000 |
| Mud/Brine | $ 10,000 |
| Frac Tanks | $ 8,500 |
| Wireline | $ 30,500 |
| Final Mechanical Integrity Test and Casing Logs | $ 75,000 |
| Cement | $ 210,000 |
| Bridge Plugs/Packers | $ 75,000 |
| Casing Crew | $ 15,000 |
| Miscellaneous | $ 58,000 |
| Subtotal ($/well) | $ 597,000 |
| **Total (6 wells)** | **$ 3,582,000** |

#### *4.2.1.3 PISC and Site Closure*

The PISC and site closure cost estimates shown in Table 4.8 and include costs for the post injection period related to the monitoring described in *Section 4.6.* The site closure costs include plugging the six monitoring wells for an estimated $522,000 per well as described in Table 4.9, and surface facility closure costs for six facilities for an estimated $600,000 per facility.

Table 4.8—Financial assurance cost estimations for PISC and site closure.

| Post-Injection Site-Care (50 years) | |
|---|---|
| 2D Time-lapse Seismic Surveys (72 miles, $39 M/mile, once) | $ 2,808,000 |
| Groundwater Monitoring ($20 M/year/3 wells) | $ 1,200,000 |
| Operations and Maintenance of Monitoring wells (6 wells) | $ 12,960,000 |
| Subtotal | $ 16,968,000 |
| **Site Closure** | |
| Monitor Well Plugging (6 wells) | $ 3,132,000 |
| Surface Facilities Closure (6 facilities) | $ 3,600,000 |
| Subtotal | $ 6,732,000 |
| **Total** | **$ 23,700,000** |

Table 4.9—Financial assurance cost estimations for monitoring well plugging.

| Monitoring Well P&A Cost Estimate | |
|---|---|
| Workover Rig | $ 100,000 |
| Rental Tools | $ 15,000 |
| Mud/Brine | $ 10,000 |
| Frac Tanks | $ 8,500 |
| Wireline | $ 30,500 |
| Final Mechanical Integrity Test and Casing Logs | $ 75,000 |
| Cement | $ 210,000 |
| Casing Crew | $ 15,000 |
| Miscellaneous | $ 58,000 |
| Subtotal ($/well) | $ 522,000 |
| **Total (6 wells)** | **$ 3,132,000** |

#### *4.2.1.4 Emergency and Remedial Response*

The Emergency Remedial Response (ERR) Financial Assurance Costs estimation was performed by Industrial Economics, Inc. (IEc) and the summary of the Monte Carlo outputs, including the maximum outcome for ERR used in Table 4.5, is provided in Table 4.10. The maximum cost over 50,000 trials was $5,248,291 (for the Spirea plume only) and serves as the ERR estimated total cost pursuant to Chapter 24 §25. IEc believes this estimate to be reasonable and appropriately conservative. The basis for the IEc cost estimates is discussed in greater detail in the report included in Exhibit 1 of *Appendix G*.

Table 4.10—Financial assurance cost statistical outcomes for emergency and remedial response.

| Emergency and Remedial Response Cost Estimation | |
|---|---|
| Average | $ 200,681 |
| Standard Deviation | $ 443,031 |
| 5th Percentile | $ 0 |
| 50th Percentile | $ 0 |
| 95th Percentile | $ 1,274,390 |
| 99th Percentile | $ 1,923,872 |
| Minimum | $ 0 |
| Maximum | $ 5,248,291 |
| **Coverage Total (maximum)** | **$ 5,248,291** |

### *4.2.2 Financial Assurance Instruments*

The financial assurance instruments will be submitted during the application phase of the project and on the required forms.

#### *4.2.2.1 Public Liability Insurance*

High Plains will obtain and maintain public liability insurance for the EWS Hub (six injection and six monitoring wells listed in Table 4.4) to meet the requirements of Wyoming Statutes **§35-11-**

**313(f)(ii)(O)** and WYDEQ Chapter 24 **§26(l)(i)(B)**; identify each facility by name, address, and EPA Identification Number; and identify the amounts and types of coverage for the facility.

High Plains will request quotes for policies conforming to these specimens with a limit of liability of $15 million as required by the Wyoming rule. High Plains respectfully seeks the opportunity to negotiate a pollution liability limit that reflects the risk-adjusted, conservative estimate of $14.6 million ($9.4 million for Old Barberry I-1, Barberry I-1, Cypress I-1, Azalea I-1 and Juniper I-1, and $5.2 million for Spirea I-1), consistent with Wyoming's cost estimation protocols, and as cited in the IEc's ERR/event-based risk activity analyses (included in Exhibit 1 of Appendix G).

The Pollution Legal Liability policy will cover the Emergency and Remedial Response costs portion of the financial assurance liability. The policy will be arranged by Marsh USA LLC, a subsidiary of Marsh McLennan, and provided by Ascot. Six CCS Support Letters (one letter per injection well) are provided in Exhibit 2 of Appendix G. The specimen policy and certificate of insurance from Ascot are provided in Exhibit 3 of Appendix G.

#### *4.2.2.2 Surety Bond*

Berkley Surety has confirmed that High Plains will be able to obtain a surety bond for the coverage of the remaining financial assurance items, per the letter provided in Exhibit 4 of Appendix G.

### 4.3 Testing and Monitoring Plan

The following Testing and Monitoring Plan is designed to meet the requirements of WYDEQ Chapter 24 **§20** of the WYDEQ Water Quality Rules and Regulations. This plan aims to ensure that the sequestering of $CO_2$ is operating as planned, the $CO_2$ plume is developing as projected, and the USDWs remain protected. The monitoring results will also be used to refine and update the plume model as necessary.

This monitoring program will be periodically reviewed at least once every five years and will consider any operational data collected, including the most recent AoR. The plan will also be amended following significant changes to the EWS Hub, such as the addition of monitoring wells and new injection wells within the AoR and within one year after an AoR reevaluation. The amended plan will be submitted to the Administrator or demonstrate that no amendments to the Testing and Monitoring Plan are needed.

High Plains will create and retain records of all monitoring information. This information will include the following:

1. Date, time, and location of all samplings or measurements.
2. Individuals who performed samplings or measurements.
3. Dates of when analyses were performed.
4. Individuals who performed analyses.
5. Analytical techniques or methods used.

This section discusses the critical details of this program, as summarized in Table 4.11.

Table 4.11—Overview of monitoring program.

| Monitoring Type | Monitoring Program | Target Structure/Project Area |
|---|---|---|
| $CO_2$ Injection Stream Composition | • $CO_2$ sampling station | Upstream or downstream of the flowmeter |
| $CO_2$ Flow Line | • Corrosion coupon monitoring | Capture facility to the well site |
| Continuous Recording of Injection Pressure, Rate, and Volume | • Surface pressure and temperature gauges<br>• Coriolis mass flowmeter near the wellhead | Surface-to-reservoir (injection well) |
| Well Annulus Pressure Between Tubing and Casing | • Annular pressure gauge for continuous monitoring | Surface-to-reservoir (injection well) |
| Atmospheric Monitoring | • $CO_2$ monitoring stations | Surface |
| Near-Surface Monitoring | • Groundwater wells in the AoR, monitoring well | Near-surface environment, USDW's |
| Above Confining Zone Monitoring | • Monitoring well with fiber optic and gauges behind casing | The first permeable formation above confining zone |
| Direct Reservoir Monitoring | • Fiber optic (DTS) and gauges behind casing—temperature, reservoir pressures<br>• Pressure falloff test (injector) | Injection zone, primary sealing formation, above confining zone |
| Indirect Reservoir Monitoring | • Pulsed neutron logging | USDW's, above confining zone, Injection zone. |
| Indirect Reservoir Monitoring | • 2D time-lapse seismic surveys | Entire storage complex |
| Internal and External Mechanical Integrity | • Annulus pressure test<br>• Temperature logs<br>• Pulsed neutron logging<br>• Casing pressure test<br>• Ultrasonic logs | Well infrastructure |
| Corrosion Monitoring | • Corrosion coupon system | Well infrastructure |
| Seismicity Monitoring | • USGS Seismic Stations | Entire storage complex |

### *4.3.1 Analysis of Injected $CO_2$ and Injection Well Testing*

High Plains will collect continuous samples of the $CO_2$ injection stream and perform analysis to meet the requirements of WYDEQ Chapter 24 **§20(b)(i)**, to obtain data representative of the injectate stream's chemical and physical characteristics. The purpose of analyzing the $CO_2$ stream is to evaluate potential interactions of carbon dioxide and other components of the injectate.

The $CO_2$ stream must meet High Plains' pipeline specifications and will be approximately 95% $CO_2$. Table 4.12 identifies the chemical components that will be analyzed from the injection stream.

Table 4.12—Chemical components targeted for characterization in the injected $CO_2$.

| Components |
|---|
| $CO_2$ |
| Methane |
| Ethane |
| Propane |
| n-Butane |
| Hydrogen |
| Nitrogen |
| Sulfur |
| Oxygen |
| Water (ppm) |

Sampling Methods

The $CO_2$ stream samples will be continuously collected from the $CO_2$ pipeline using a gas chromatograph on the flowline before the injection flowmeter.

#### *4.3.1.1 Injection Well Integrity Tests*

Before beginning injection, and as required, the following tests will be run to ensure well integrity. Per WYDEQ Chapter 24 **§17(e),** High Plains will provide the Administrator with the opportunity to witness the logging and testing discussed in this section. High Plains will submit a schedule of these activities to the Administrator prior to conducting the first test and submit any changes to the schedule 30 days prior to the next scheduled test.

**1. Cement Evaluation and Casing Inspection Logs**

Per the requirements in WYDEQ Chapter 24 **§17(a)(ii)(B)** and **§17(a)(iii)(B),** cement bond logs and variable density logs will be run after each casing string (surface and long) is set and cemented. These logs will be used to evaluate cement quality radially and will have sufficient resolution to identify channels, voids, or areas of missing cement, and a temperature log—after the casing is set and cemented.

Per the requirements in WYDEQ Chapter 24 **§17(a)(iv)(D)**, casing inspection logs will be run after the surface casing and long string is set and cemented. Casing inspection logs will then be run every five years or as the tubing is removed for workover operations. The following logging tools will be run:

- Cement Bond Log (CBL).

- Through-tubing inspection log upon installation of tubing and packer.
- Multiple-armed calipers to measure the inner diameter of the casing as the tool is raised or lowered into the well.
- Ultrasonic tools to measure wall thickness and provide information about the outer surface of the casing or tubing, the quality of the cement bonding, and the presence of cement channeling or micro annulus (optional).
- Electromagnetic tools that measure the magnetic flux of the tubulars and can provide mapped circumferential images to indicate potential pitting (optional).

Evaluation

High Plains will provide the CBL to the Administrator with an evaluation, certified by a licensed professional engineer or a licensed professional geologist of the following:

- Quantitative estimations of the cement compressive strength.
- A bond index.
- Qualitative interpretation of the cement-to formation bond.

**2. Pressure Fall-off Testing**

Per the requirements of WYDEQ Chapter 24 **§17(d)** and **§20(b)(vii)**, High Plains will conduct a baseline pressure falloff test before injection and then every five years. The data provided from these tests will be used to measure formation properties near the injection well and monitor for any near-wellbore environment changes that may impact injectivity and increase pressures.

Testing Method

The injection rate and pressure for the well will be consistently maintained and continuously recorded before the pressure falloff test begins. Once the well is shut in, continuous pressure measurements will be recorded from two BHP gauges. The second gauge will be used as a backup and for verification in the event of data inconsistencies. The falloff period will continue until radial flow conditions are observed, as indicated by a straight line of pressure decay on a semi-log plot.

Analytical Methods

The calculation of specific near-wellbore conditions, including well skin, prevailing flow regimes, and hydraulic property and boundary conditions, will be determined from standard diagnostic log-log and semi-log plots. Performing baseline pressure falloff testing before injection allows for future comparison of subsequent tests and indicates whether significant changes in the well or reservoir conditions have occurred. Such analysis will consider the impact of two-phase flow effects. The parameters determined from the falloff tests will be compared to those used in the site computational modeling and AoR determination. The AoR will be reevaluated if any significant changes in reservoir properties are identified.

Quality Assurance/Control

All field equipment will be inspected and tested before use, and the pressure gauges used in the falloff test will be calibrated per manufacturers' recommendations. Calibration certificates will be provided with the test results. The use of the second BHP gauge will provide further validation of the test results.

The results of the pressure falloff tests will be submitted to the Administrator within 30 days of the test.

### 3. Mechanical Integrity Testing—Annulus Pressure Test

Per the requirements of WYDEQ Chapter 24 **§19(b),** High Plains will perform internal mechanical integrity tests (MITs) before initial injection and after any subsequent workovers. These annular pressure tests will be performed to demonstrate the mechanical integrity of the casing, tubing, and packer at the initial completion and after any workovers.

Testing Procedure

The annulus between the casing and tubing will be pressured to a minimum of 1,000 psi (fluid pressure). Once the test has started, a block valve will be used to isolate the test pressure source from the test pressure gauge, and all the ports into the casing annulus will be closed except the one used for monitoring the test pressure gauge. The test pressure will be monitored and recorded for a minimum of 30 minutes. A loss of test pressure greater than 10% during the minimum 30 minutes will indicate a potential lack of mechanical integrity and will be further reviewed for mitigation needs. The pressure gauge used during the test will be sensitive enough to show a loss of 10%.

The results of this annulus pressure test will be reported to the Administrator within 30 days of the test.

### 4. External Mechanical Integrity Testing—Temperature

As required by WYDEQ Chapter 24 **§24.19(c)** and **§24.20(b)(v),** a fiberoptic (DTS) temperature log will be recorded and archived annually to determine the absence of significant fluid movement, thus ensuring mechanical integrity. Before beginning injection operations, a temperature baseline will be established for future comparisons.

Testing Procedure

The well will be shut in until the temperatures have stabilized, at approximately 36 hours before running the temperature log. Correlation between the baseline and subsequent logs will demonstrate mechanical integrity.

Temperature logs will be provided to the Administrator within 30 days after the log is run.

### *4.3.2 Corrosion Monitoring and Prevention Plan*

#### 1. Corrosion Prevention Plan

As described in *Section 4.4*, the composition of the injectate stream and the injection formation fluids will be considered in determining the appropriate metallurgy for the tubing and long-casing string. Additionally, acid-resistant cement and packer fluids will be used to minimize corrosion in the injection well.

#### 2. Corrosion Coupon Monitoring

To meet the requirements of WYDEQ Chapter 24 **§20(b)(iii),** High Plains will conduct corrosion monitoring of the well's tubing, casing, and pipeline materials using a corrosion coupon monitoring system. This process will monitor for loss of mass and thickness, cracking, pitting, and other signs of corrosion, and ensure that the well components meet the minimum material strength and performance standards as specified in WYDEQ Chapter 24 **§14(b).**

Sampling Methods

Corrosion coupons, made of the same material as the production casing and the injection tubing, will be placed in the $CO_2$ injection pipeline downstream of any processing equipment. The coupons will be removed quarterly and assessed for corrosion using American Society for Testing and Materials (ASTM) standards at a certified laboratory. When the coupons are removed, they will be inspected visually for any signs of corrosion, including pitting. The weight and size of the coupons will be measured each time they are removed. The corrosion rate will be calculated using a weight loss method where the rate equals the weight loss during the exposure period divided by the duration of the period.

Other Methods

Casing inspection logs, annulus pressure tests, and temperature logs will be run as described in *Section 4.3.1*, in addition to the corrosion coupon monitoring.

### *4.3.3 Surface Leak Detection and Monitoring Plan*

Surface equipment at the injection site will be monitored with $CO_2$ leak detection equipment. The areas to be monitored include the wellhead and the $CO_2$ flowline. The $CO_2$ detection system will be monitored using a SCADA system that will alert system operators of any conditions that may require the operator to adjust or intervene. $CO_2$ detectors will be located at the injection wellhead and around the EWS Hub. The surface leak detection equipment will be part of the automated warning system and inspected and tested every six months. If any detection equipment is determined to have issues, it will be repaired or replaced as soon as possible. The operator will maintain all inspection reports and make them available to the Administrator as requested.

### *4.3.4 Subsurface Leak Detection and Monitoring Plan*

Pressure falloff tests, as described in *Section 4.3*, will be performed every five years to monitor for changes in the near-wellbore environment that could indicate the presence of a subsurface leak. Surface monitoring, groundwater monitoring, and continuous pressure and temperature data from the monitoring well will all be used to analyze any leak detections above the confining interval.

The Spirea M-1 will act as the monitoring well for the Spirea I-1 well, as shown in Figure 1.1. Spirea M-1 will monitor above the injection and confining intervals. As described in *Appendix D—Quality Assurance and Surveillance Plan*, pressure and temperature gauges will be installed on tubing encapsulated conductor (TEC) line parallel to a fiber optic cable outside the production casing. These gauges will monitor for any changes in the reservoir parameters that would indicate movement of $CO_2$ into the Sundance Formation and provide data to validate and calibrate the plume model.

Groundwater sampling will further monitor for subsurface leaks, as described in the following sections.

### *4.3.5 Near-Surface Groundwater Monitoring*

To determine the possibility of $CO_2$ movement from the injection zone into the USDW and above, High Plains will monitor and routinely sample three groundwater wells per injector within the EWS Hub. This plan is described in detail in Section 4.3.7.

### *4.3.6 Completed Baseline Sampling Program*

#### 1. Groundwater Baseline Sampling

A comprehensive groundwater monitoring plan includes a baseline sampling program followed by annual sampling. The baseline sampling period will consist of sufficient samples taken over several months to determine the expected levels of $CO_2$ present and other key compositional parameters present in the groundwater before injection starts. The frequency and duration of the baseline sampling program will be designed to account for seasonal fluctuations. The samples will be taken at locations across the AoR (Table 4.13). Initial measurements will be taken at temporary locations until permanent sample sites are developed. In addition to baseline sampling, annual groundwater sampling will be conducted and results will be compared to the baseline results.

Table 4.13—Baseline groundwater sampling results.

| **Parameter** | **pH (s.u.)** | | | **SpC (mS/cm)** | | | **Alkalinity as $CaCO_3$ (ppm)** | | |
|---|---|---|---|---|---|---|---|---|---|
| Well No. | Date | Date | Date | Date | Date | Date | Date | Date | Date |
| TBD | | | | | | | | | |

### *4.3.7 Near-Surface (Groundwater) Monitoring Plan*

Table 4.14 describes the proposed soil, air, and shallow groundwater monitoring program.

In addition to the $CO_2$ injector and deep monitoring well, each wellsite is planned to have three (3) USDW monitoring wells (Figure 4.3). These USDW wells will be placed near the corners or to the side of the well pad, about 125 to 150 ft from the injector well, out of the way of other equipment, wellsite piping, and vehicle traffic. The three USDW wells will be completed in different depths or horizons. USDW-1, 2, and 3 (well numbers arbitrary) will be drilled to about 100, 250, and 1,000 ft, respectively. These depths are expected to allow water quality monitoring for 1) the Alluvium and Terrace deposits near surface, 2) the Ogallala, Arikaree and White River regional aquifers, and 3) the Lance and Fox Hills deposits.

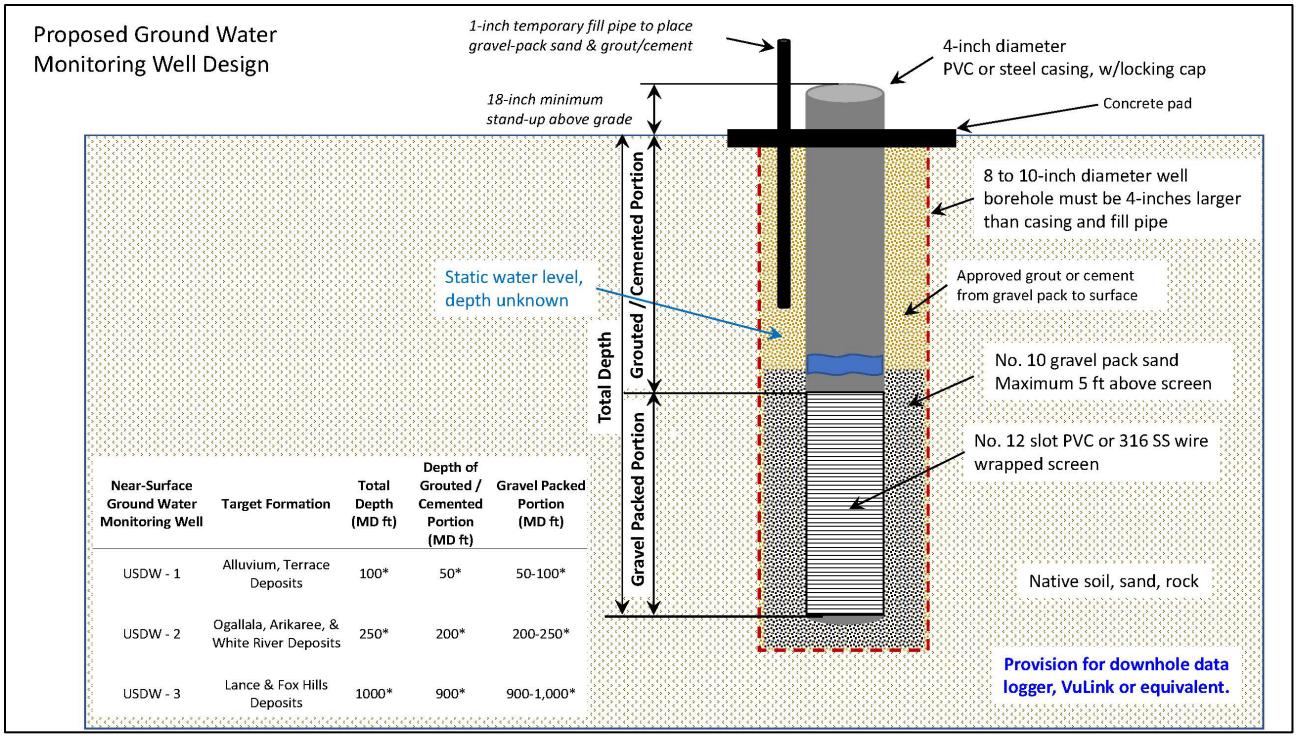
The wells will be constructed in accordance with the Water Well Minimum Construction Standards, issued in June 2011, Wyoming State Engineer's Office. The Type III gravel pack well design explained in this subject document will be the design of choice. The gravel pack, combined with corrosion resistant materials, will ensure long service life.

The water quality monitoring will be accomplished primarily with installation of a data logger to detect water level, pH, specific gravity, specific electrical conductivity, and temperature. Any disturbance of the ground water at the site, especially any leakage of $CO_2$, will affect these parameters for real time detection. In addition, physical water samples can be collected for laboratory analysis, on an as required basis. $CO_2$ in air monitors will also be placed to monitor the air above the water level in each of these monitoring wells. The shallow, 100 ft., well could have a water level within the gravel-pack screen interval allowing this USDW well to serve as a vadose-zone monitoring as well as water quality monitoring station.

High Plains has determined that a soil gas monitoring plan is not necessary to monitor potential leakage. The risk of endangerment to a USDW is minimal given the low risk of migration of fluids out of the injection zone and the Lyons injection zone monitoring plan, thus a soil gas monitoring plan will not be the first means of identification of a leak. The Chugwater and Goose Egg confining zones are excellent seals with a combined 539 ft of gross thickness and average effective porosity of 1–2% and average permeability of 0.01 mD. No transmissive faults or fractures have been identified, which is supported by the pressure difference observed between the Lyons injection zone and the Sundance, the first permeable zone above the confining layer within the AoR.

Table 4.14—Baseline (pre-injection), operational, and post-operational monitoring.

| Monitoring Type | Baseline (Pre-injection) | Operational | Post-Operational |
|---|---|---|---|
| **Soil Monitoring** | | | |
| Soil Monitoring Sensors | Not applicable | Not applicable | Not applicable |
| **Air Monitoring** | | | |
| Air Monitoring Sensors | Not Applicable | Not applicable | Not applicable |
| **Water Monitoring** | | | |
| Three freshwater wells | Duration: 1 year<br>Frequency: Annual | Duration: During injection operations<br>Frequency: Bi-Annual | Duration: Until approved to cease monitoring<br>Frequency: Annual |




| Near-Surface Ground Water Monitoring Well | Target Formation | Total Depth (MD ft) | Depth of Grouted / Cemented Portion (MD ft) | Gravel Packed Portion (MD ft) |
|---|---|---|---|---|
| USDW - 1 | Alluvium, Terrace Deposits | 100* | 50* | 50-100* |
| USDW - 2 | Ogallala, Arikaree, & White River Deposits | 250* | 200* | 200-250* |
| USDW - 3 | Lance & Fox Hills Deposits | 1000* | 900* | 900-1,000* |

* Depths are approximate and will be finalized and assigned during the drilling and completion operations

Figure 4.3—Proposed well design for the three shallow groundwater monitoring wells.

### *4.3.8 Deep Subsurface Monitoring of Free-Phase $CO_2$ Plume and Pressure Front*

Direct and indirect monitoring methods will be used to track the extent of the $CO_2$ plume within the injection formation throughout the injection and post-injection monitoring periods, per the methods described in Table 4.15. As data is gathered, the plume model will be updated at a minimum of every two years during the injection period and every five years post-injection. The AoR will be updated as indicated by the model's results. Monitoring results will be used to calibrate the geological and plume model inputs through historical matching between predicted and actual results.

The Spirea M-1 is located in the predicted direction of plume movement and will serve as the above injection zone monitoring well for the EWS Hub. It will be equipped with multiple pressure gauges and DTS/DAS/DSS (distributed strain sensing) fiber optic technology to continuously monitor pressure and temperature above the upper confining zone.

Table 4.15—Description of monitoring program.

| Monitoring Type | Pre-operational (Baseline) | Operational | Post-Operational |
|---|---|---|---|
| **Storage Reservoir Monitoring** | | | |
| Monitoring During Injection Well Operations:<br>• Flow rates<br>• Volumes<br>• Surface injection pressure | Frequency: Initial setup | Duration: 5 years<br>Frequency: Continuously | The well will be plugged and abandoned after injection operations cease. Measurements will continue until the well is plugged. |

| Monitoring Type | Pre-operational (Baseline) | Operational | Post-Operational |
|---|---|---|---|
| • Surface injectate temperature<br>• Annulus pressure between tubing and long-string<br>• Added annulus volumes | | | |
| Packer Fluid (Corrosion Inhibitor) Volume | Record the initial volume of packer fluid necessary to fill the casing/tubing annulus. | Record if additional volumes are needed to fill the annulus. Test the effectiveness of corrosion inhibitors, as needed, during workover operations. | The well will be plugged and abandoned after injection operations cease. Fluid levels will be monitored until the well is plugged. |
| **Downhole Monitoring (Injection Well and Monitoring Well(s))** | | | |
| Pressures and temperature gauges on fiber optic behind casing (Spirea M-1) | Baseline measurements of the temperature and pressures in the injection interval | Continuous pressure and temperature monitoring | Continuous temperature and pressure measurements until plume stabilization |
| **Wireline Logging and Retrievable Monitoring** | | | |
| Internal Mechanical Integrity: Tubing-Casing Annulus Pressure Test | Mechanical integrity test before injection | Perform during workovers | Before P&A |
| External Mechanical Integrity—Casing Inspection Logging | Baseline casing inspection logs before injection | Duration: 5 years<br>Frequency: Every five years across injection interval and during any workover options | At the cessation of injection and before P&A of the injection well. At the end of injection and every five years afterward until the plume stabilizes. |
| External Mechanical Integrity—Downhole Temperature Logging; DTS on fiber optic cable | Baseline temperature logging through the storage interval to surface (injection and monitoring well) | Through-tubing logging in injection and monitoring wells annually | Annual temperature logging until plume stabilization |
| Pressure Fall-Off Test (Injection Zone) | Before injection | Every five years at the injection well | Before P&A |
| Corrosion Monitoring | Baseline material specifications | Quarterly samples obtained from corrosion coupons placed in the $CO_2$ stream | N/A |
| **Geophysical Monitoring** | | | |
| Time-Lapse 2D Seismic Survey | Baseline from existing 2D surveys | Once during injection to confirm models | Once during PISC to confirm plume stabilization |

A description of the tests and methods used will be included in the mechanical integrity reports submitted to the Administrator.

### *4.3.9 Direct Monitoring Methods*

The $CO_2$ plume will be directly monitored by temperature and pressure gauges placed via TEC line as well as a fiber optics system behind the casing in both the injection well and the monitoring well. These gauges will continuously measure the reservoir temperature and pressures for the injection zone and the upper confining interval. Changes in the temperature and pressure within the injection zone allow for the validation and calibration of the plume model. Monitoring of the upper confining layer in Spirea M-1 can provide an early indication that fluids may be migrating out of the injection zone, thus allowing time to adjust the planned injection, to ensure the fluids do not impact a USDW or reach the surface.

### *4.3.10 Indirect Monitoring Methods*

The extent of the $CO_2$ plume will be monitored using time-lapse 2D seismic surveys. High Plains will establish a baseline view of the injection interval and then subsequent surveys will be acquired during injection for use in simulation model updates. Additionally, post injection, subsequent surveys will be acquired to confirm the plume stabilization. These data and interpretations will be compared to those from the baseline surveys to determine the extent of the $CO_2$ plume. The acquired data will also be used to refine the plume model and update the AoR. The 2D surveys acquired once injection begins will be designed to cover the expected plume area in a spoke-like fashion, as shown in Figure 4.4.

High Plains plans to utilize DTS in the Spirea M-1 annually to monitor all zones above the injection zone. Due to the high-resolution nature of this tool, this method of monitoring will inform High Plains of any carbon dioxide or saline fluids migrating out of the injection zone.

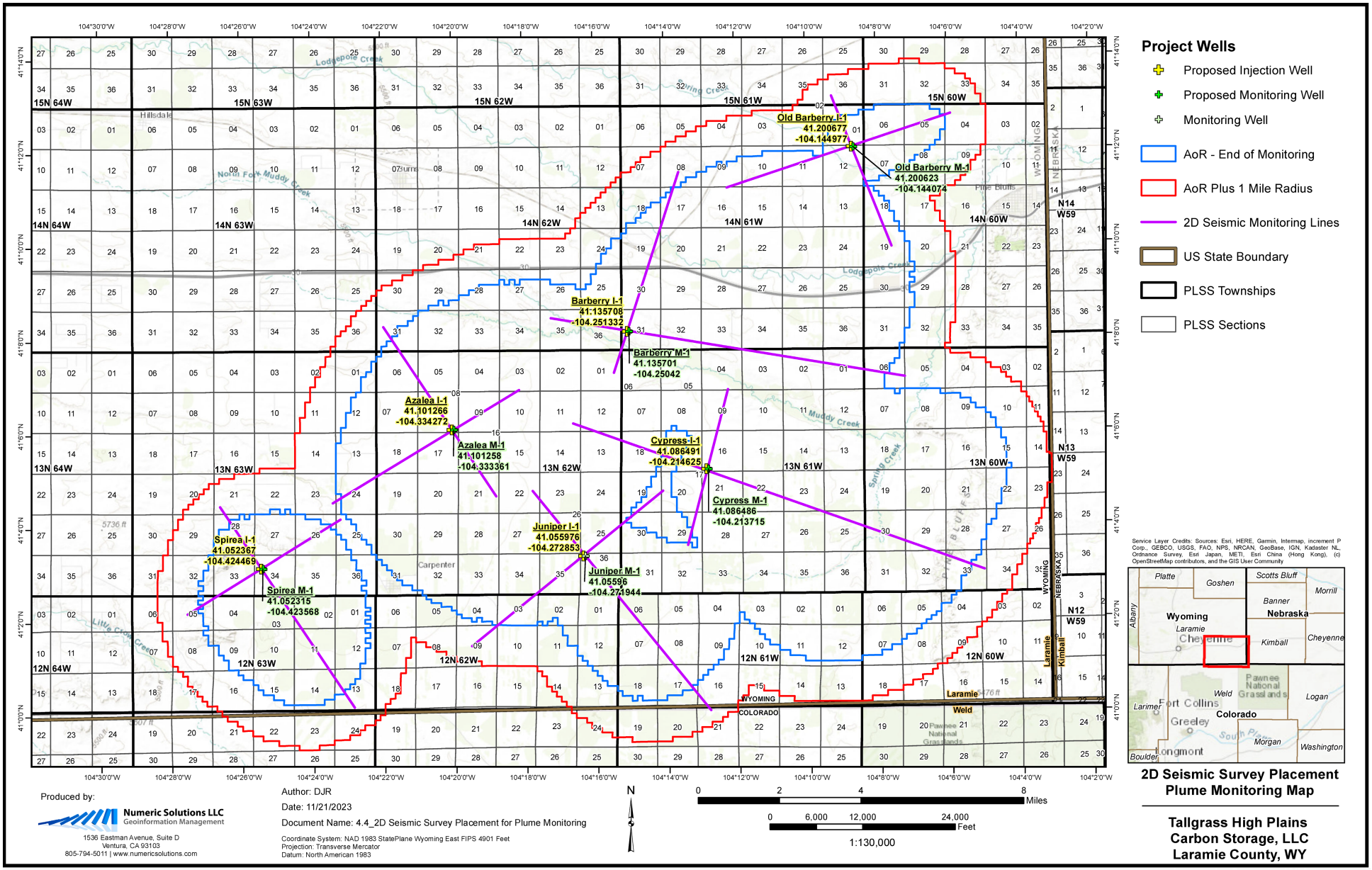



Figure 4.4—2D seismic survey placement for plume monitoring.

### *4.3.11 Quality Assurance and Surveillance Plan*

This Testing and Monitoring Plan aims to ensure that the sequestering of $CO_2$ is operating as planned, the $CO_2$ plume is developing as projected, and the USDWs remain protected from fluid migration. The Quality Assurance and Surveillance Plan is included in *Appendix D.*

### *4.3.12 Records Retention*

High Plains will maintain records, per WYDEQ Chapter 24 **§21,** for the EWS Hub according to the following schedule shown in Table 4.16.

Table 4.16—EWS Hub records retention schedule.

| Record Description | Minimum Retention Period |
|---|---|
| Calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit | 3 years from date of sample |
| The nature and composition of all injected fluids | 10 years after the completion of any P&A procedures |
| Well plugging reports, site closure report, and any post-injection site care data (including data and information used to establish the post-injection site care time frame) | 10 years following site closure |
| All data used to complete permit applications | 10 years following site closure |
| All other monitoring records required by a permit | 10 years following site closure |

All retained records will be delivered to the Administrator at the conclusion of the retention period.

### *4.3.13 Reporting and Notice Requirements*

Per WYDEQ Chapter 24 **§22**, High Plains will provide semi-annual reports, 30-day reports, and 24-hour reports to the Administrator:

- Semi-annual Reports (within 30 days) will include:
    - Any changes to the physical, chemical, and other relevant characteristics of the carbon dioxide stream from the proposed operating data;
    - Monthly average, maximum, and minimum values for injection pressure, flow rate and volume, and annular pressure;
    - A description of any event that exceeds operating parameters for annulus pressure or injection pressure specified in the permit;
    - The monthly volume of the carbon dioxide stream injected over the reporting period and project cumulatively;

    - Monthly annulus fluid volume added; and
    - The monitoring results as described in Section 4.3.
- 30-Day Reports will include:
    - Periodic tests of mechanical integrity;
    - Any other test of the injection well conducted by the owner or operator as required by the Administrator; and
    - Any well workover.
- 24-Hour Reports will include:
    - Any evidence that the injected carbon dioxide stream or associated pressure front may cause an endangerment to a USDW; any non compliance with a permit condition, or malfunction of the injection system, which may cause fluid migration into or between USDWs;
    - Any triggering of a shut-off system, either down-hole or at the surface;
    - Any release of carbon dioxide to the atmosphere or biosphere indicated by the surface air; and
    - Any failure to maintain mechanical integrity.

High Plains will notify the Administrator, in writing, 30 days before:

- Any planned well workover;
- Any planned stimulation activities, other than stimulation for formation testing; or
- Any other planned test of the injection well conducted by High Plains.

Pending the results of the reservoir quality testing program, artificial stimulation techniques may be proposed to reduce skin and increase permeability. Proposed artificial stimulation techniques will maintain seal integrity and may include perforation, acid, and fracture stimulation. A stimulation program will be executed upon DEQ approval. An example of a mud acid work over is provided in *Appendix J*. Proposed stimulation techniques may be executed over the injection period of the project.

## 4.4 Well Casing and Cementing Program

### *4.4.1 Proposed $CO_2$ Injection Well Casing and Cementing Programs*

Permanently sequestering and preventing movement of the $CO_2$ injectate into the USDW is a critical design criterion for Class VI wells. The design and operation of Spirea I-1 considers the injection volume, rate, chemical composition, and physical properties of the injectate fluid as well as the corrosive nature of the injectate fluid and its interaction with wellbore components. Operation of the Spirea I-1 will manage pore space utilization in the reservoir and contain injected $CO_2$ in the authorized injection interval for the life of the project.

Specialty metallurgy is often required to handle the potential for corrosive fluids. $CO_2$ alone is not corrosive, but when combined with water and other chemical compounds such as hydrogen sulfide ($H_2S$), it can create carbonic acid with a pH as low as 3. The metallurgy selection for the Spirea I-1 considers the injectate makeup and is designed to withstand the potentially harsh

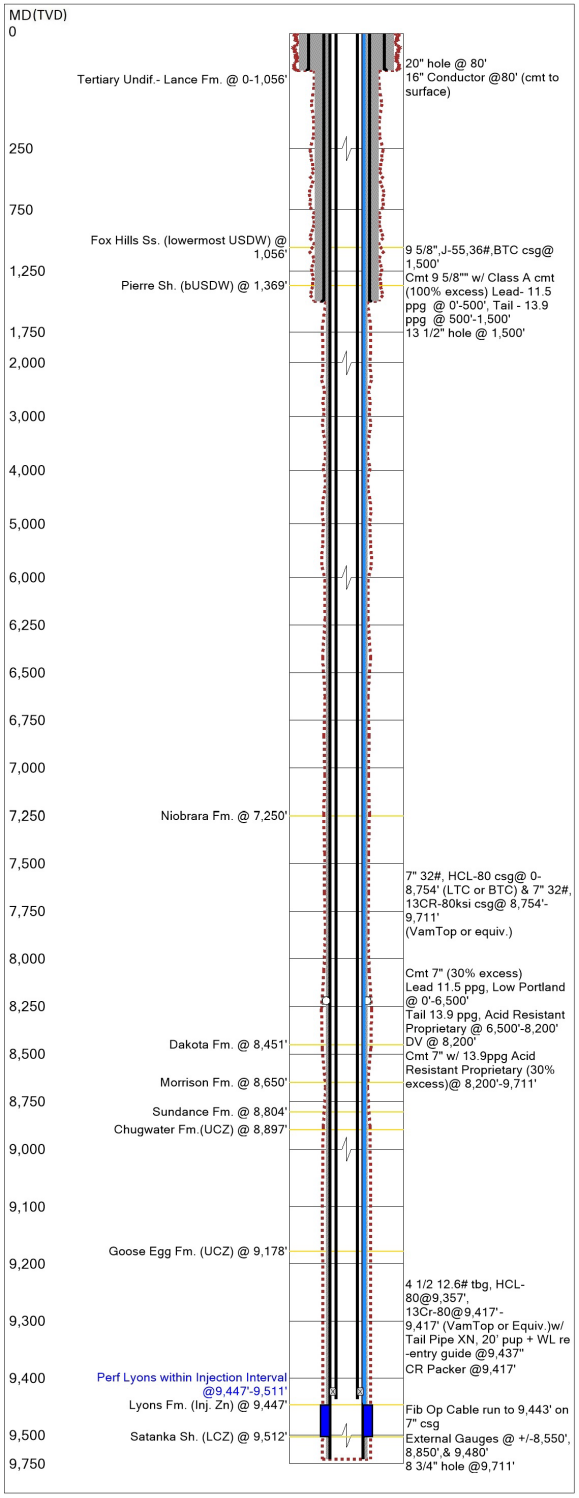
environment presented by injecting $CO_2$. The casing and cement are engineered to protect the USDW and prevent the injectate fluids from migrating out of the injection interval.

The Spirea I-1 well design will meet or exceed the following standards:

- American Petroleum Institute (API) Specification 5CT
- API RP 5C1
- API RP 10B-2
- API Specification 10A
- API RP 10D-2
- API Specification 11D1
- API RP 14B
- API RP 14C

The proposed well design is a vertical well. A deviated well design may be proposed to maximize storage volumes. This design would be proposed if reservoir data suggests a lower quality reservoir than currently understood. The well design would be proposed to and approved by WDEQ.

Figure 4.5 represents the proposed wellbore schematic for the Spirea I-1.




| Field Name | Lease Name | Well No. |
|---|---|---|
| Trailblazer | Spirea | I-1 |

| County | State | API No. |
|---|---|---|
| Laramie | WY | |

| GL (ft) | KB (ft) | Section | Township/Block | Range/Survey |
|---|---|---|---|---|
| 5,435.0 | | 34 | 13N | 63W |

| Operator | Well Type | Well Status |
|---|---|---|
| Tallgrass High Plains Carbon Storage, LLC | Injector | Proposed |

| Latitude | Longitude |
|---|---|
| 41.052367 | -104.424469 |

**Hole Summary**

| Date | Diam. (in) | Top (MD ft) | Bottom (MD ft) | Memo |
|---|---|---|---|---|
| | 20.000 | 0 | 80 | |
| | 13.500 | 80 | 1,500 | |
| | 8.750 | 1,500 | 9,711 | |

**Tubular Summary**

| Coupling | Description | OD (in) | Wt (lb/ft) | Grade | Top (MD ft) | Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|---|
| | Conductor Casing | 16.000 | 65.00 | | 0 | 80 | C |
| BTC | Surface Casing | 9.625 | 36.00 | J-55 | 0 | 1,500 | C |
| LTC or BTC | Production Casing | 7.000 | 32.00 | HCL-80 | 0 | 8,754 | C |
| VamTop or Equiv. | Tubing | 4.500 | 12.60 | HCL-80 | 0 | 9,357 | C |
| VamTop or Equiv. | Tubing | 4.500 | 12.60 | 13CR-80 | 9,357 | 9,417 | C |
| VamTop or Equiv. | Tubing | 4.500 | 12.60 | 13CR-80 | 9,417 | 9,437 | C |
| VamTop or Equiv. | Production Casing | 7.000 | 32.00 | 13CR-80ksi | 8,754 | 9,711 | C |

**Casing Cement Summary**

| C | Date | No. Sx | Csg. OD (in) | Top (MD ft) | Bottom (MD ft) | Memo | RL |
|---|---|---|---|---|---|---|---|
| | | 540 | 7.000 | 0 | 6,500 | Lead - Low Portland | C |
| | | 213 | 9.625 | 0 | 500 | Class A Cement to Surface , Lead | C |
| | | | 16.000 | 0 | 80 | Cmt to surface | C |
| | | 724 | 9.625 | 500 | 1,500 | Class A Cement to Surface, Tail | C |
| | | 280 | 7.000 | 6,500 | 8,200 | Tail - Acid Resistant Proprietary | C |
| | | 252 | 7.000 | 8,200 | 9,711 | Acid Resistant Proprietary | C |

**Tools/Problems Summary**

| Date | Tool Type | OD (in) | ID (in) | Top (MD ft) | Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|
| | DV Tool | 7.000 | | 8,200 | | C |
| | Fib Op Cable | | | 0 | 9,443 | C |
| | Ext. Csg Gauges | | | 8,550 | 9,480 | C |
| | CRA Pkr | 7.000 | 4.500 | 9,417 | | C |

**Perforation Summary**

| C | Date | Perf. Status | Formation | OA Top (MD ft) | OA Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|
| | | Open | Lyons Fm. (Inj. Zn) | 9,447 | 9,511 | C |

Figure 4.5—Proposed wellbore schematic for Spirea I-1.

Table 4.17—Injection well information (referenced below ground surface in feet).

| Well Name | Injection Zone Formation Name(s) | Injection Well Total Depth (ft) | Injection Zone Depths (ft) |
|---|---|---|---|
| Spirea I-1 | Lyons Sandstone | 9,711 | 9,447–9,511 |

The proposed wellbore design consists of 9 ⅝ in. surface casing run below the base of the lowermost confirmed USDW and will be cemented in place per EPA Class VI standards. The production casing will be a 7 in. run to an approximate depth of 9,711 ft across the planned injection zones in the Lyons Sand. The injection zone will span between 9,447 ft and 9,511 ft (Table 4.17). To ensure sufficient corrosion resistance for $CO_2$ injection, corrosion-resistant alloy (CRA) material will be used across the injection zone and upper confining interval.

Like the casing string, it is important to consider the injectate and the potential for a corrosive environment when selecting the metallurgy of the tubing. Although the injectate stream is anticipated to be dry and non-corrosive, the planned design allows for the possibility of a surface upset or invasion of connate water from the reservoir. Taking into consideration the possibility of a water and $CO_2$ mixture leading to the presence of carbonic acid, the lower portion of the injection string will be comprised of 4 ½ in. CRA tubulars and a 4 ½ in. CRA retrievable injection packer.

Details of the well design are shown in Table 4.18 to Table 4.20.

Table 4.18—Proposed Spirea I-1 casing and tubing program.

| Section | Hole Size (in) | Casing OD (in) | Weight (lb/ft) | Grade | Connection | Top Depth (ft) | Bottom Depth (ft) | Objective |
|---|---|---|---|---|---|---|---|---|
| Conductor | 20 | 16 | 65 | | | 0 | 80 | |
| Surface | 13 ½ | 9 ⅝ | 36 | J-55 | BTC | 0 | 1,500 | Protect lowermost confirmed USDW (Fox Hills) |
| Long (top) | 8 ¾ | 7 | 32 | HCL-80 | LTC or BTC | 0 | 8,754 | Connection from surface and isolation |
| Long (bottom) | 8 ¾ | 7 | 32 | 13Cr-80 | *VAM TOP | 8,754 | 9,711 | Cover confining interval and injection zone with CRA |
| Tubing | N/A | 4 ½ | 12.6 | L-80 | *VAM TOP | 0 | 9,357 | Pump $CO_2$ to injection zone |
| Tubing | N/A | 4 ½ | 12.6 | 13 Cr-80 | *VAM TOP | 9,357 | 9,437 | Pump $CO_2$ to injection zone |

*Or equivalent

Table 4.19—Proposed Spirea I-1 casing properties.

| OD (in) | Grade | Weight (lb/ft) | Connection | ID (in) | Drift (in) | Burst (psi) | Collapse (psi) | Yield Strength, 1,000 lb | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Body | Connection |
| 9 ⅝” | J-55 | 36 | BTC | 8.921 | 8.765 | 3,520 | 2,020 | 564 | 639 |
| 7” | HCL-80 | 32 | LTC | 6.094 | 5.969 | 9,060 | 10,400 | 745 | 738 |
| 7” | 13Cr-80 | 32 | *VAM TOP | 6.094 | 6.000 | 9,060 | 8,610 | 745 | 745 |

*Or equivalent

Table 4.20—Proposed Spirea I-1 cement program.

| Hole Size (in.) | Casing Size and Weight (in., lb/ft) | Lead | | | Tail | | | Excess |
|---|---|---|---|---|---|---|---|---|
| | | Slurry | Interval (ft) | Sacks* | Slurry | Interval (ft) | Sacks* | |
| 13 ½ | 9 ⅝ in., 36 lb/ft | 11.5 ppg, Class A | 0–500 | 213 | 13.5 ppg, Class A | 500–1,500 | 724 | 100% |
| 8 ¾ | 7 in., 32 lb/ft | 13.5 ppg, Low Portland | 0–6,500 | 540 | 13.9 ppg acid Resistant Proprietary | 6,500–8,200 | 280 | 30% |
| Cementing Stage Tool set @ 8,200 ft | | | | | | | | |
| 8 ¾ | 7 in., 32 lb/ft | N/A | N/A | N/A | 13.9 ppg Acid Resistant Proprietary | 8,200–9,711 | 252 | 30% |

*Cement yields used here are subject to adjustment

The following proposed logging program (Table 4.21) is designed to meet the requirements of WYDEQ Chapter 24 **§17(a)**. Per WYDEQ Chapter 24 **§17(e),** High Plains will provide the Administrator with the opportunity to witness the logging and testing discussed in this section. High Plains will submit a schedule of these activities to the Administrator prior to conducting the first test and submit any changes to the schedule 30 days prior to the next scheduled test.

Table 4.21—Spirea I-1 proposed logging program.

| Hole Section | Trip | Logging Suite | Target Data Acquisition |
|---|---|---|---|
| Surface 0 ft to 1,500 ft (Open Hole) | S1 | Gamma Ray | Identification of Rock Properties |
| | | Caliper | |
| | | Resistivity | |
| | | Density | |
| | | Neutron | |
| | | Sonic/Acoustic | |
| Surface 0 ft to 1,500 ft (Cased Hole) | S2 | Cement Bond Log w/VDL display | Annular cement placement and bond quality |
| | S3 | Temperature Log | |
| Pilot 1,500 ft to TD (Open Hole) | P1 | Resistivity | Identification of Rock Properties |
| | | Density | |
| | | Neutron | |
| | | Gamma Ray | |
| | | | Log tie back |
| | | Deviation Survey | Wellbore position |
| | | Multi-arm Caliper | Aid in Cement Calcs |
| | | Sonic/Acoustic | Mechanical Properties and Synthetic Ties |
| | P2 | Oil-based Image Log | Fracture/Fault/Structure |
| | P3 | Ultrasonic Image Log | |
| | P4 | MDT | Formation Fluid Samples, Pressure Measurements |
| | | Wireline Formation Tester (WFT) | |
| | P5 | Sidewall Coring tool | Sidewall Cores |
| | | Gamma Ray | Log tie back to previous runs |
| Pilot 1,500 ft to TD (Cased Hole) | P6 | Cement Bond Log | Well Integrity Baseline |
| | P7 | Temperature Log | Mechanical integrity baseline |
| | P8 | Magnetic Flux / Casing Inspection Log | |

**Mechanical Integrity Testing—Annulus Pressure Test**

In accordance with WYDEQ Chapter 24 **§19**, High Plains will ensure mechanical integrity by performing annular pressure tests after the well has been completed, before the start of injection, and after any workover operation involving the removal and replacement of the tubing and packer.

The annular pressure tests should demonstrate the mechanical integrity of the casing, tubing, and packer. These tests are conducted by pressuring the annulus to a minimum of 1000 psi, or to the permitted Limited Surface Injection Pressure (LSIP), whichever is less. Once the test has started a block valve will be used to isolate the test pressure source from the test pressure gauge, and all ports into the casing annulus closed except the one monitored by the test pressure gauge. The test pressure will be monitored and recorded for a minimum duration of 30 minutes using a pressure gauge with sensitivities that can indicate a loss of 10%. A lack of mechanical integrity is indicated by any loss of test pressure exceeding 10% during a minimum elapsed period of 30 minutes.

Tests run by operators in the absence of the WYDEQ inspector must be conducted according to these procedures. All annulus pressure test results will be submitted to the Administrator within 30 days of log run completion.

**External Mechanical Integrity Testing—Temperature Log**

In adherence to the requirements of WYDEQ Chapter 24 **§19**, High Plains will perform an annual external MIT by conducting a temperature log, through the tubing or utilizing the fiber optic cable and DTS. Temperature logs will be run before initiating injection operations to establish a baseline against which future logs can be compared. The well will be shut in for a duration of approximately 36 hours prior to running the temperature logs to allow temperatures to stabilize. Satisfactory mechanical integrity is demonstrated by the proper correlation between the baseline and subsequent logs.

Tests run by operators in the absence of the WYDEQ inspector must be conducted according to these procedures. All temperature logs recorded during the MIT will be submitted to the WYDEQ within 30 days of log run completion.

### *4.4.2 Proposed Monitoring Well Casing and Cementing Programs*

Spirea M-1 is planned to monitor above the confining zone from injection in Spirea I-1. This well is located on the same pad as Spirea I-1. The casing and cement is designed for corrosion-resistance and to protect against movement of $CO_2$ or brine into USDWs. The well will be drilled through the Sundance and will penetrate the top of the Chugwater. The Spirea M-1 will not penetrate into the Lyons and will be equipped with fiber optics and gauges external to the casing to monitor for any fluid migration above the top of the Chugwater. The information contained in this section are the details of the proposed well design.

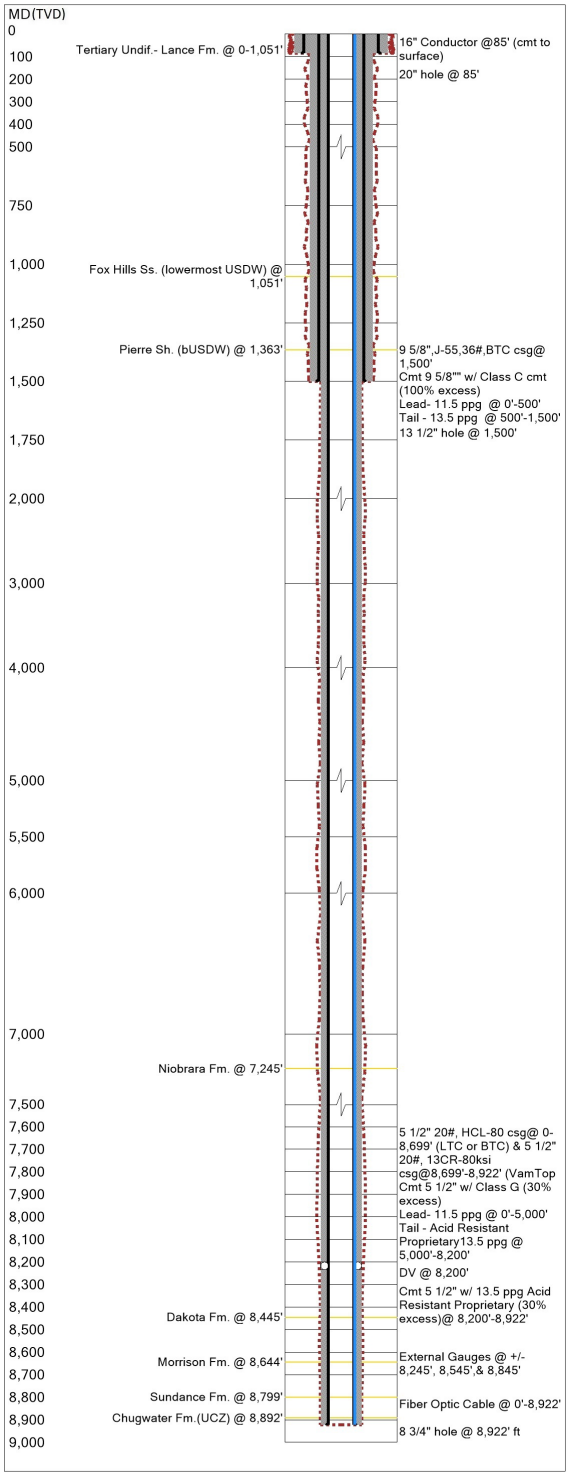
Table 4.22—Proposed monitoring well.

| Proposed Above Zone Monitoring Well Location | | | | | | |
|---|---|---|---|---|---|---|
| **Well Name** | **County** | **Latitude** | **Longitude** | **Section** | **Township** | **Range** |
| Spirea M-1 | Laramie | 41.052315 | -104.423568 | 34 | 13N | 63W |

Figure 4.6 and Table 4.23 to 4.19 provide the schematics, construction details, and logging plans for the monitoring well based on proposed designs.

*Spirea M-1*

Spirea M-1 will be drilled 30 ft into the Chugwater and will have fiber optic cable with conventional temperature and pressure sensors run behind the production casing string.




| Field Name | Lease Name | Well No. |
|---|---|---|
| Trailblazer | Spirea | M-1 |

| County | State | API No. |
|---|---|---|
| Laramie | WY | |

| GL (ft) | KB (ft) | Section | Township/Block | Range/Survey |
|---|---|---|---|---|
| 5,431.0 | | 34 | 13N | 63W |

| Operator | Well Type | Well Status |
|---|---|---|
| Tallgrass High Plains Carbon Storage, LLC | Monitor | Proposed |

| Latitude | Longitude |
|---|---|
| 41.052315 | -104.423568 |

**Hole Summary**

| Date | Diam. (in) | Top (MD ft) | Bottom (MD ft) | Memo |
|---|---|---|---|---|
| | 20.000 | 0 | 85 | |
| | 13.500 | 85 | 1,500 | |
| | 8.750 | 1,500 | 8,922 | |

**Tubular Summary**

| Coupling | Description | OD (in) | Wt (lb/ft) | Grade | Top (MD ft) | Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|---|
| | Conductor Casing | 16.000 | 65.00 | | 0 | 85 | C |
| BTC | Surface Casing | 9.625 | 36.00 | J-55 | 0 | 1,500 | C |
| LTC | Production Casing | 5.500 | 20.00 | HCL-80 | 0 | 8,699 | C |
| VamTop or Equiv. | Production Casing | 5.500 | 20.00 | 13CR-80ksi | 8,699 | 8,922 | C |

**Casing Cement Summary**

| C | Date | No. Sx* | Csg. OD (in) | Top (MD ft) | Bottom (MD ft) | Memo | RL |
|---|---|---|---|---|---|---|---|
| | | 1,609 | 5.500 | 0 | 5,000 | Lead - Low Portland | C |
| | | 407 | 9.625 | 0 | 500 | Class C Cement to Surface , Lead | C |
| | | 56 | 16.000 | 0 | 85 | Cmt to surface | C |
| | | 815 | 9.625 | 500 | 1,500 | Class C Cement to Surface, Tail | C |
| | | 1,010 | 5.500 | 5,000 | 8,200 | Tail - Acid Resistant Proprietary | C |
| | | 198 | 5.500 | 8,200 | 8,922 | Acid Resistant Proprietary | C |

**Tools/Problems Summary**

| Date | Tool Type | OD (in) | ID (in) | Top (MD ft) | Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|
| | DV Tool | | | 8,200 | | C |
| | Fib Op Cable | | | 0 | 8,922 | C |
| | Ext. Csg Gauges | | | 8,245 | 8,845 | C |

*Cement yield of 1.2 cuft/sx is utilized here, cement yield is subject to adjustment

Figure 4.6—Proposed schematic for the Spirea M-1 well.

Table 4.23—Proposed Spirea M-1 casing and tubing program.

| Section | Hole Size (in) | Casing OD (in) | Weight (lb/ft) | Grade | Connection | Top Depth (ft) | Bottom Depth (ft) | Objective |
|---|---|---|---|---|---|---|---|---|
| Surface | 13 ½ | 9 ⅝ | 36 | J-55 | BTC | 0 | 1,500 | Protect lowermost USDW |
| Long | 8 ¾ | 5 ½ | 20 | HCL-80 | LTC | 0 | 8,699 | Connection from surface and isolation |
| Long | 8 ¾ | 5 ½ | 20 | 13CR-80ksi | Vam Top HT* | 8,699 | 8,922 | Connection from surface and isolation |

*Or equivalent

Table 4.24—Proposed Spirea M-1 casing properties.

| OD (in) | Grade | Weight, (lb/ft) | Connection | ID (in) | Drift (in) | Burst (psi) | Collapse (psi) | Yield Strength, 1,000 lb | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Body | Connection |
| 9-⅝ | J-55 | 36 | BTC | 8.921 | 8.765 | 3,520 | 2020 | 564 | 639 |
| 5-½ | HCL-80 | 20 | LTC | 4.778 | 4.653 | 9,190 | 10,630 | 466 | 438 |
| 5-½ | 13CR-80ksi | 20 | Vam Top* | 4.778 | 4.653 | 9,190 | 8,830 | 466 | 466 |

*Or equivalent

Table 4.25—Proposed Spirea M-1 cement program.

| Hole Size (in) | Casing Size and Weight (in., lb/ft) | Lead | | | Tail | | | Excess |
|---|---|---|---|---|---|---|---|---|
| | | Slurry | Interval (ft) | Sacks* | Slurry | Interval (ft) | Sacks* | |
| 13 ½ | 9 ⅝, 36 | 11.5 ppg, Class C | 0-500 | 407 | 13.5 ppg, Class C | 500-1,500 | 815 | 100% |
| 8 ¾ | 5 ½, 20 | 11.5 ppg, Class G | 0-5,000 | 1,609 | 13.5 ppg acid resistant Class G | 5,000-8,200 | 1,010 | 50% |
| | | Cementing Stage Tool set @ 8,200 ft | | | | | | |
| 8 ¾ | 5 ½, 20 | 13.5 ppg acid resistant Class G | 8,200-8,922 | 198 | N/A | 0 | | 30% |

*Cement yield of 1.2 $ft^3$/sack is utilized here, cement yield is subject to adjustment

The following proposed log program was designed prior to the logging operations to meet the requirements of WYDEQ Chapter 24 **§17(a)**:

Table 4.26—Proposed logging plan for Spirea M-1

| Hole Section | Trip | Logging Suite | Target Data Acquisition |
|---|---|---|---|
| Surface 0 ft to 1,500 ft (Open Hole) | S1 | Gamma Ray | Identification of Rock Properties |
| | | Caliper | |
| | | Resistivity | |
| | | Density | |
| | | Neutron | |
| | | Sonic/Acoustic | |
| Surface 0 ft to 1,500 ft (Cased Hole) | S2 | Cement Bond Log w/VDL display | Annular cement placement and bond quality |
| | S3 | Temperature Log | |
| Pilot 1,500 ft to TD (Open Hole) | P1 | Resistivity | Identification of Rock Properties |
| | | Density | |
| | | Neutron | |
| | | Gamma Ray | |
| | | | Log tie back |
| | | Deviation Survey | Wellbore position |
| | | Multi-arm Caliper | Aid in Cement Calcs |
| | | Sonic/Acoustic | Mechanical Properties and Synthetic Ties |
| | P2 | Oil-based Image Log | Fracture/Fault/Structure |
| | P3 | Ultrasonic Image Log | |
| | P4 | MDT | Formation Fluid Samples, Pressure Measurements |
| | | Wireline Formation Tester (WFT) | |
| | P5 | Sidewall Coring tool | Sidewall Cores |
| | | Gamma Ray | Log tie back to previous runs |
| Pilot 1,500 ft to TD (Cased Hole) | P6 | Cement Bond Log | Well Integrity Baseline |
| | P7 | Temperature Log | Mechanical integrity baseline |
| | P8 | Magnetic Flux / Casing Inspection Log | |

### *4.4.3 Monitoring Well Completion Details*

#### 1. Coring Plan

High Plains collected whole cores during the drilling of the stratigraphic test well, Juniper M-1. The core point began at approximately 50 ft above the Sundance Formation in the Morrison Formation. Core samples were taken from 8,478 ft to 9,270 ft. The cores collected include the base of the Morrison, Chugwater, Goose Egg, Lyons, and Satanka formations. Sidewall cores were also collected in the Juniper M-1. High Plains does not plan to core the Spirea M-1 well.

#### 2. Fluid Sample Plan

During the drilling and completion of the stratigraphic test well, the Juniper M-1, SLB's SRS tool was run to collect fluid samples across the Lyons Formation to confirm it is not a USDW and to provide baseline geochemical information. High Plains has no plans to collect fluid samples from subsequent monitoring wells and will instead collect fluid samples from relevant formations in all injection wells within the EWS Hub.

#### 3. Mechanical Integrity Testing—Annulus Pressure Test

In accordance with **WYDEQ Chapter 24 §19**, High Plains will demonstrate mechanical integrity by performing annular pressure tests after the well has been completed, before injection, and after any workover operation involving the removal and replacement of the tubing and packer.

The annular pressure tests should demonstrate mechanical integrity of the casing, tubing, and packer. These tests are conducted by pressuring the annulus to a minimum of 500 psi fluid pressure, then using a block valve to isolate the test pressure source from the test pressure gauge upon test initiation, with all ports into the casing annulus closed except the one monitored by the test pressure gauge. The test pressure will be monitored and recorded for a minimum of 30 minutes, using a pressure gauge with sensitivities that can indicate a loss of 10%. A lack of mechanical integrity is indicated by any loss of test pressure exceeding 10% during that minimum duration.

Tests run by operators in the absence of the WYDEQ inspector must be conducted according to these procedures. All annulus pressure test results will be submitted to the WYDEQ within 30 days of log run completion.

#### 4. External Mechanical Integrity Testing—Temperature Log

In adherence to the requirements of WYDEQ Chapter 24 **§19**, High Plains will perform an annual external MIT by conducting a temperature log through tubing or utilize the fiber optics with DTS. Temperature logs will be run before initiating injection operations to establish a baseline against which future logs can be compared. The well will be shut in for approximately 36 hours prior to running the temperature logs, to allow temperatures to stabilize. Satisfactory mechanical integrity is demonstrated by proper correlation between the baseline and subsequent logs.

Tests run by operators in the absence of the WYDEQ inspector must be conducted according to these procedures. All temperature logs recorded during the MIT will be submitted to the WYDEQ within 30 days of log run completion.

### 4.5 Plugging Plan

This section provides an overview of plugging operations after injection operations have ceased at Spirea I-1. High Plains intends to properly plug and abandon the injection well under the requirements of WYDEQ Chapter 24 **§23.** In addition to regulatory requirements, sound engineering and operational practices will be applied during this program to prevent fluid migration and contamination of the USDW. All materials used during this plugging operation will be compatible with carbon dioxide and carbon dioxide-water mixtures. The procedure outlines the plugging plan, including notification, the wellbore preparation, and the final plugging and abandonment procedure. After the abandonment operations, a notarized Subsequent Report of Abandonment (Form 4, Sundry Notice) will be filed with the Administrator within 30 days of the plugging date, per the WOGCC Chapter 3 **§17.** The report will include the following:

1. Certification of completion in accordance with approved plans and specifications by a licensed professional engineer or licensed professional geologist.
2. Certification of accuracy by the owner or operator and by the person who performed the plugging operation.

**Pre-Plugging Procedures**

1. **Issue Notifications**
    a. Notify the Administrator at least 60 days before plugging a well (WYDEQ Chapter 24 **§23(d)**).
    b. Provide a revised plugging plan that will capture changes and revisions that are not projected at the time of this draft.
    c. Notify the Administrator at least 24 hours in advance of the Blow Out Preventer (BOP) test.
2. **Determination of Bottomhole Reservoir Pressure** (WYDEQ Chapter 24 **§23(a)**)

    Bottomhole pressure will be measured with a wireline gauge run through tubing. The well should be shut in for a sufficient time to ensure the reservoir pressures are stabilized.

3. **External Mechanical Integrity Testing and Well Flush** (WYDEQ Chapter 24 **§23(b)(ii)**)

    External mechanical integrity will be demonstrated through approved temperature logging methods. The following procedure is to demonstrate mechanical integrity, release packer, recover tubing, and clean out the wellbore.

    a. Shut in injection well and move in and rig up workover rig and equipment.
    b. Kill and flush well (WYDEQ Chapter 24 **§23(a)**).
        i. Determine appropriate $CO_2$-compatible fluid based on BHP reading.
        ii. Bullhead buffer fluid selected based on BHP down 4 ½ in. production tubing.

iii. Pump wellbore volume plus 50 barrels (bbl) to flush into formation.
iv. Ensure well has achieved static equilibrium.

c. Install back-pressure valve (BPV) in the tubing hanger.
d. Nipple-down the wellhead.
e. Nipple-up the BOP.
f. Function test the BOP.
g. Conduct a low-pressure test of the BOP system at 250 psi.
    i. Pressure must not decrease more than 10 psi during a five-minute test period.
h. Conduct a high-pressure test of the BOP system at the maximum working pressure.
    i. Pressure must not decrease more than 10 psi during the five-minute test period.
i. Document pressure and times on the daily reports or provide third-party test reports with daily reports.
    i. Bleed pressure, remove joint of work string, and remove test plug.
j. Move in and rig up (MIRU) wireline, pressure control, and logging tools.
k. Perform approved temperature logging to confirm wellbore integrity.
    i. If integrity cannot be confirmed, prepare, and submit a remediation plan for approval.
l. Pressure test casing (tubing-casing annulus) with packer fluid to maximum established well casing operating pressure, to ensure integrity.
m. Run tubing punch on wireline and punch tubing just above the packer. Circulate well and annulus to kill weight fluid.
n. Make up a landing joint to tubing hanger or spear the tubing if necessary.
o. Run a mechanical cutter on wireline and cut the retrievable packer mandrel.
p. Rig down wireline.
q. Pick up tubing hanger and release the packer.
r. Pull out of hole laying down tubing and packer.
s. Pick up 7 in. casing scraper with the workstring.
t. Run in hole with casing scraper to the top perforation.
u. Pull out of hole racking back the workstring.
v. Rig up wireline pressure control equipment and logging tools.
w. Run casing inspection log and cement bond log.
x. Evaluate logs and confirm wellbore integrity.

### *4.5.1 $CO_2$ Injection Well Plugging and Abandonment Program*

**a. Isolate Lyons Formation**

i. Rig up setting tool and 7 in. cement retainer on workstring (WOGCC Chapter 3 **§18(b)(iii)(B)**).
ii. Run in hole and set cement retainer at ± 9,397 ft.
    1. Set 50 ft above the top perforation.
    2. Set at least 5 ft from collar.

iii. Rig up cementing equipment.
iv. Mix and pump volume to be no less than the volume between the retainer and deepest perforation (114 ft) plus 50% excess cement volume squeezing cement into the perforations while staying below 90% of formation fracture gradient. Set corrosion-resistant cement plug from 9,397–9,511 ft. Sting out from retainer and place 200 ft corrosion-resistant plug from 9,397ft–9,197 ft.
    1. Below retainer: $CO_2$ compatible cement—29 Sacks, 35 $ft^3$
    2. Above retainer: $CO_2$ compatible cement—34 Sacks, 41 $ft^3$
v. Pull out of hole to 9,000 ft and reverse circulate to clear cement from workstring and wait on cement.
vi. Run in hole and tag top of cement plug at ±9,197 ft.
    1. If the plug is tagged deeper than expected or does not pass the pressure test, additional cement may be required.
vii. Pressure up to 500 psig and record the chart for 30 minutes.
viii. Pull out of hole.

**b. Set confinement zone plug.**

i. Make up and run in hole with corrosion-resistant alloy bridge plug. Set the plug 50 ft above the bottom of the Chugwater at ±9,127 ft Make up and run in hole with workstring to 9,127 ft.
ii. Rig up cementing equipment.
iii. Mix and pump 200 ft plug from 9,127 ft to 8,927 ft TOC.
    1. $CO_2$ compatible cement—34 Sacks, 41 $ft^3$.
iv. Pull out of hole to 8,800 ft and reverse circulate to clear cement from the workstring and wait on cement.
v. Run in hole and tag plug at ±8,927 ft.
vi. Pressure up to 500 psig chart for 30 minutes.

**c. Set intermediate plug #1.**

i. Pull out of hole with workstring to 6,527 ft.
ii. Rig up cementing equipment.
iii. Mix and pump 200 ft plug from 6,527 ft to 6,327 ft TOC.
    1. $CO_2$ compatible cement—34 Sacks, 41 $ft^3$.
iv. Pull out of hole to 6,200 ft and reverse circulate to clear cement from the workstring and wait on cement.
v. Run in hole and tag plug at ±6,327 ft.
vi. Pressure up to 500 psig chart for 30 minutes.

**d. Set intermediate plug #2.**

i. Pull out of hole with workstring to 3,927 ft.
ii. Rig up cementing equipment.
iii. Mix and pump 200 ft plug from 3,927 ft to 3,727 ft TOC.
    1. $CO_2$ compatible cement—34 Sacks, 41 $ft^3$.

iv. Pull out of hole to 3,600 ft and reverse circulate to clear cement from the workstring and wait on cement.
v. Run in hole and tag plug at ±3,727 ft.
vi. Pressure up to 500 psig chart for 30 minutes.

**e. Set plug across surface shoe.**

i. Position workstring in hole to 1,550 ft.
ii. Mix and pump 200 ft plug from 1,550 ft to 1,350 ft TOC.
    1. $CO_2$ compatible cement—34 sacks of cement, 41 $ft^3$
iii. Pull out of hole to 1,200 ft and reverse circulate to clear cement from the workstring and wait on cement.
iv. Run in hole and tag to of cement plug at ±1,350 ft TOC.
v. If the plug is tagged deeper than expected or does not pass pressure test, additional cement may be required.
vi. Pressure up to 500 psig chart for 30 minutes.
vii. Pull out of hole.

**f. Set USDW plug.**

i. Run in hole to 1,350 ft.
ii. Mix and pump 200 ft balanced cement plug from 1,350 ft to 1,150ft (paired with the last plug, this plug achieves putting cement 50 ft below to at least 150 ft into the lowermost confirmed USDW).
    1. $CO_2$ compatible cement—34 sacks, 41 $ft^3$
iii. Pull out of hole to 1,000 ft and reverse circulate to clear cement from workstring and wait on cement.
iv. Run in hole and tag cement plug at ±1,150 ft.
    1. If the plug is tagged deeper than expected or does not pressure test, additional cement may be required.
v. Pressure up to 500 psi and chart for 30 minutes.

**g. Set surface plug.**

i. Pull out of hole, laying down workstring to 200 ft.
ii. Mix and pump the 200 ft balanced cement plug from 200 ft to the surface.
    1. $CO_2$ compatible cement—34 sacks, 41 $ft^3$

**h. Nipple-down the BOP.**

**i. Cut casing at ground level and weld on ½ in. steel plate.**

**j. Erect a permanent marker on the well with the following:**

i. Company name
ii. Lease
iii. Well number
iv. Date of plugging
v. Location of the well

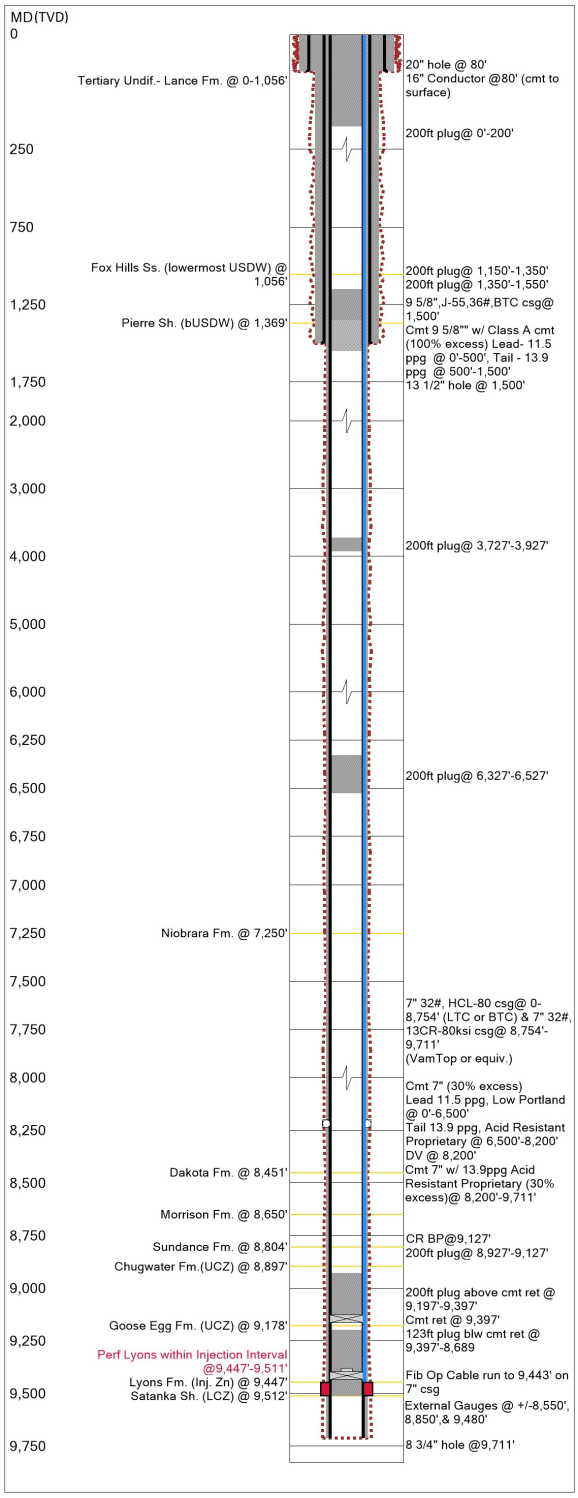
**k. Rig down and move out all equipment.**

Table 4.27 provides the plug summary and Figure 4.7 shows the proposed P&A schematic for Spirea I-1.

Table 4.27—Summary of plug and abandon plan for the injection well.

| Cement Plug Number | Interval Range (ft) | | Thickness (ft) | Volume, (sacks*) | Note |
|---|---|---|---|---|---|
| 1 | 9,511 | 9,397 | 114 | 29 | Cement retainer with 114 ft cement plug (additional 50% excess) below |
| 2 | 9,397 | 9,197 | 200 | 34 | $CO_2$ resistant cement plug set above cement retainer |
| 3 | 9,127 | 8,927 | 200 | 34 | Confinement zone cement plug set above CRA bridge plug |
| 4 | 6,527 | 6,327 | 200 | 34 | Intermediate plug #1 |
| 5 | 3,927 | 3,727 | 200 | 34 | Intermediate plug #2 |
| 6 | 1,550 | 1,350 | 200 | 34 | Cement plug set across the surface casing shoe |
| 7 | 1,350 | 1,150 | 200 | 34 | Cement plug set across the base of the lowermost confirmed USDW |
| 8 | 200 | 0 | 200 | 34 | Surface cement plug |

*Cement yield of 1.2 $ft^3$/sack is utilized here, cement yield is subject to adjustment




| Field Name | Lease Name | Well No. |
|---|---|---|
| Trailblazer | Spirea | I-1 |

| County | State | API No. |
|---|---|---|
| Laramie | WY | |

| GL (ft) | KB (ft) | Section | Township/Block | Range/Survey |
|---|---|---|---|---|
| 5,435.0 | | 34 | 13N | 63W |

| Operator | Well Type | Well Status |
|---|---|---|
| Tallgrass High Plains Carbon Storage, LLC | Injector | Proposed |

| Latitude | Longitude |
|---|---|
| 41.052367 | -104.424469 |

**Hole Summary**

| Date | Diam. (in) | Top (MD ft) | Bottom (MD ft) | Memo |
|---|---|---|---|---|
| | 20.000 | 0 | 80 | |
| | 13.500 | 80 | 1,500 | |
| | 8.750 | 1,500 | 9,711 | |

**Tubular Summary**

| Coupling | Description | OD (in) | Wt (lb/ft) | Grade | Top (MD ft) | Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|---|
| | Conductor Casing | 16.000 | 65.00 | | 0 | 80 | C |
| BTC | Surface Casing | 9.625 | 36.00 | J-55 | 0 | 1,500 | C |
| LTC or BTC | Production Casing | 7.000 | 32.00 | HCL-80 | 0 | 8,754 | C |
| VamTop or Equiv. | Production Casing | 7.000 | 32.00 | 13CR-80ksi | 8,754 | 9,711 | C |

**Casing Cement Summary**

| C | Date | No. Sx | Csg. OD (in) | Top (MD ft) | Bottom (MD ft) | Memo | RL |
|---|---|---|---|---|---|---|---|
| | | 540 | 7.000 | 0 | 6,500 | Lead - Low Portland | C |
| | | 213 | 9.625 | 0 | 500 | Class A Cement to Surface , Lead | C |
| | | | 16.000 | 0 | 80 | Cmt to surface | C |
| | | 724 | 9.625 | 500 | 1,500 | Class A Cement to Surface, Tail | C |
| | | 280 | 7.000 | 6,500 | 8,200 | Tail - Acid Resistant Proprietary | C |
| | | 252 | 7.000 | 8,200 | 9,711 | Acid Resistant Proprietary | C |

**Tools/Problems Summary**

| Date | Tool Type | OD (in) | ID (in) | Top (MD ft) | Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|
| | CR BP | 7.000 | | 9,127 | | C |
| | Cmt Ret | 7.000 | | 9,397 | | C |
| | DV Tool | 7.000 | | 8,200 | | C |
| | Fib Op Cable | | | 0 | 9,443 | C |
| | Ext. Casing Gauges | | | 8,550 | 9,480 | C |

**Cement Plug Summary**

| C | Date | No. Sx* | OD (in) | Top (MD ft) | Bottom (MD ft) | Memo | RL |
|---|---|---|---|---|---|---|---|
| | | 34 | 7.000 | 0 | 200 | | C |
| | | 34 | 7.000 | 1,150 | 1,350 | | C |
| | | 34 | 7.000 | 1,350 | 1,550 | | C |
| | | 34 | 7.000 | 3,727 | 3,927 | | C |
| | | 34 | 7.000 | 6,327 | 6,527 | | C |
| | | 34 | 7.000 | 8,927 | 9,127 | | C |
| | | 34 | 7.000 | 9,197 | 9,397 | | C |
| | | 29 | 7.000 | 9,397 | 9,511 | | C |

**Perforation Summary**

| C | Date | Perf. Status | Formation | OA Top (MD ft) | OA Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|
| | | Isolated | Lyons Fm. (Inj. Zn) | 9,447 | 9,511 | C |

*Cement yield of 1.2 cuft/sx is utilized here, cement yield is subject to adjustment

Figure 4.7—Proposed plug and abandon schematic for the Spirea I-1 well.

### *4.5.2 Monitoring Well Plugging and Abandonment Program*

After the PISC phase of the Class VI project—and as the primary part of site closure activities—the monitoring well will be abandoned. The monitoring well will be appropriately plugged and abandoned under the requirements of WYDEQ Chapter 24 **§23**. In addition to regulatory requirements, sound engineering and operational practices will be applied during this program to prevent fluid migration and contamination of the USDW. The procedure outlines the plugging plan to include notification, preparation of the wellbore, and the final plugging and abandonment procedure. After the abandonment operations, a notarized Subsequent Report of Abandonment (Form 4, Sundry Notice) will be filed with the Administrator within 30 days of the plugging date per WOGCC Chapter 3 **§17.** The report will include the following:

Certification of completion in accordance with approved plans and specifications by a licensed professional engineer or licensed professional geologist

Certification of accuracy by the owner or operator and by the person who performed the plugging operation.

#### *4.5.2.1 Plugging Plan, Monitoring Well*

**Pre-plugging Procedures** (for monitoring well)

1. **Issue notifications.**
    a. Notify the Administrator at least 60 days before plugging a well (WYDEQ Chapter 24 §23(d)).
    b. Provide a revised plugging plan that will capture changes and revisions that are not projected at the time of this draft.
    **c.** Notify the Administrator at least 24 hours in advance of the BOP test.
2. **Determination of bottomhole reservoir pressure (WYDEQ Chapter 24 §23(a)).**

    This well is to serve as a monitoring well with fiber optics and conventional pressure and temperature gauges cemented outside the 5 ½ in. casing string. The well is not expected to be perforated or open to any formation and the total depth at drilling and completion was to be above the containment layers for the Lyons sequestration reservoir. Bottom hole pressure should be only the hydrostatic pressure from well fluid but will be verified during the mechanical integrity check in the next section.

3. **External mechanical integrity testing and well flush (WYDEQ Chapter 24 §23(b)(ii)).**

    External mechanical integrity will be demonstrated through approved temperature logging methods.

    a. Move in and rig up wireline BOP and lubricator.
        i. By design, this well has no tubing installed to allow potential logging operations from surface, in addition to the fiber optics and conventional pressure and temperature gauges cemented behind the casing.
    b. Perform approved temperature logging to confirm wellbore integrity.

i. If integrity cannot be confirmed, prepare and submit to the Director for approval an intervention and remediation plan for approval.

c. Set a back pressure valve in the tubing-hanger profile.
d. Move in and rig up a workover rig and ancillary equipment.
e. Nipple down the tree and install and test a BOP.
f. Pick up and RIH with a 5 ½ in. casing scraper on a workstring to TD.
g. Pressure test casing to 500 psi to ensure integrity.
h. Pull out of hole racking back workstring and lay down casing scraper.
i. Rig up wireline, pressure control equipment and logging tools.
j. Run casing inspection log and cement bond log.
    i. Evaluate logs and confirm wellbore integrity.

*4.5.2.2 Monitoring Well Plugging and Abandonment Program—Spirea M-1*

**4. Set bottom plug.**

i. Make up and run in hole with workstring to 8,922 ft
ii. Rig up cementing equipment.
iii. Mix and pump 300 ft plug from 8,922 ft to 8,622 ft TOC.
    1. Class G —31 Sacks, 37 $ft^3$.
iv. Pull out of hole to 8,500 ft and reverse circulate to clear cement from the workstring and wait on cement.
v. Run in hole and tag plug at ±8,622 ft.
vi. Pressure up to 500 psig chart for 30 minutes.

**5. Set intermediate plug #1.**

i. Pull out of hole with workstring to 6,241 ft.
ii. Rig up cementing equipment.
iii. Mix and pump 200 ft plug from 6,241 ft to 6,041 ft TOC.
    1. Class G—21 Sacks, 25 $ft^3$.
iv. Pull out of hole to 5,900 ft and reverse circulate to clear cement from the workstring and wait on cement.
v. Run in hole and tag plug at ±6,041ft.
vi. Pressure up to 500 psig chart for 30 minutes.

**6. Set intermediate plug #2.**

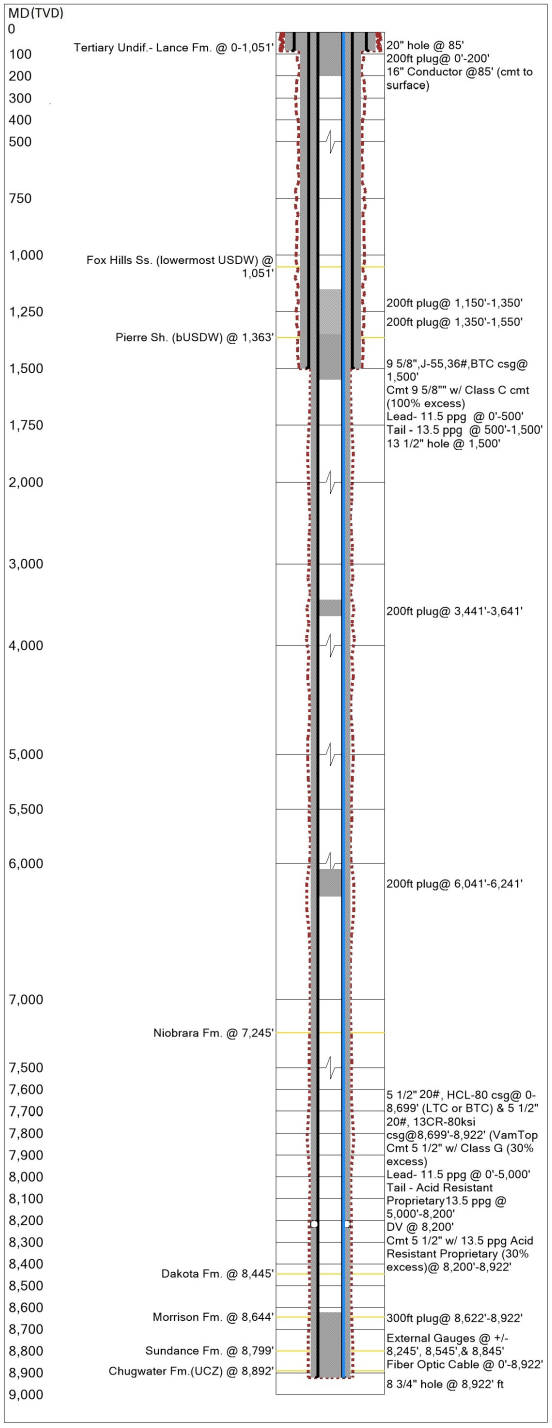
i. Pull out of hole with workstring to 3,641 ft.
ii. Rig up cementing equipment.
iii. Mix and pump 200 ft plug from 3,641 ft to 3,441 ft TOC.
    1. Class G—21 Sacks, 25 $ft^3$.
iv. Pull out of hole to 3,300 ft and reverse circulate to clear cement from the workstring and wait on cement.
v. Run in hole and tag plug at ±3,441 ft.
vi. Pressure up to 500 psig chart for 30 minutes.

7. **Set plug across surface shoe.**
    i. Position workstring in hole to 1,550 ft.
    ii. Mix and pump 200 ft plug from 1,550 ft to 1,350 ft TOC.
        1. Class G - 21 sacks of cement, 25 $ft^3$
    iii. Pull out of hole to 1,250 ft and reverse circulate to clear cement from the workstring and wait on cement.
    iv. Run in hole and tag to of cement plug at ±1,350 ft TOC.
    v. If the plug is tagged deeper than expected or does not pass pressure test, additional cement may be required.
    vi. Pressure up to 500 psig chart for 30 minutes.
    vii. Pull out of hole.
8. **Set base USDW plug.**
    i. Run in hole to 1,350 ft.
    ii. Mix and pump 200 ft balanced cement plug from 1,350 ft to 1,150ft (paired with the last plug, this plug achieves putting cement 50 ft below to at least 150 ft into the lowermost confirmed USDW).
        1. Class G—21 sacks, 25 $ft^3$
    iii. Pull out of hole to 1,000 ft and reverse circulate to clear cement from workstring and wait on cement.
    iv. Run in hole and tag cement plug at ±1,150 ft.
        1. If the plug is tagged deeper than expected or does not pressure test, additional cement may be required.
    v. Pressure up to 500 psi and chart for 30 minutes.
9. **Set surface plug.**
    i. Pull out of hole, laying down to 200 ft.
    ii. Mix and pump the 200 ft balanced cement plug from 200 ft to the surface.
        1. Class G—21 sacks, 25 $ft^3$
    **b. Nipple-down the BOP.**
    **c. Cut casing at ground level and weld on ½ in. steel plate.**
    **d. Erect a permanent marker on the well with the following:**
        i. **Company name**
        ii. **Lease**
        iii. **Well number**
        iv. **Date of plugging**
        v. **Location of the well**
    **e. Rig down and move out all equipment.**

Table 4.28 provides the plug summary and Figure 4.8—Proposed P&A schematic for the Spirea M-1 well. shows the proposed P&A schematic for Spirea M-1.

Table 4.28—Summary of PLUG AND ABANDON plan for Spirea M-1.

| Cement Plug Number | Interval Range (ft) | | Thickness (ft) | Volume (sacks) | Note |
|---|---|---|---|---|---|
| 1 | 8,922 | 8,622 | 300 | 31 | Bottom plug |
| 2 | 6,241 | 6,041 | 200 | 21 | Intermediate plug #1 |
| 3 | 3,641 | 3,441 | 200 | 21 | Intermediate plug #2 |
| 4 | 1,550 | 1,350 | 200 | 21 | Cement plug set across the surface casing shoe |
| 5 | 1,350 | 1,150 | 200 | 21 | Cement plug set across the base of the lowermost USDW |
| 6 | 200 | 0 | 200 | 21 | Surface cement plug |




| Field Name | Lease Name | Well No. |
|---|---|---|
| Trailblazer | Spirea | M-1 |

| County | State | API No. |
|---|---|---|
| Laramie | WY | |

| GL (ft) | KB (ft) | Section | Township/Block | Range/Survey |
|---|---|---|---|---|
| 5,431.0 | | 34 | 13N | 63W |

| Operator | Well Type | Well Status |
|---|---|---|
| Tallgrass High Plains Carbon Storage, LLC | Monitor | Proposed |

| Latitude | Longitude |
|---|---|
| 41.052315 | -104.423568 |

**Hole Summary**

| Date | Diam. (in) | Top (MD ft) | Bottom (MD ft) | Memo |
|---|---|---|---|---|
| | 20.000 | 0 | 85 | |
| | 13.500 | 85 | 1,500 | |
| | 8.750 | 1,500 | 8,922 | |

**Tubular Summary**

| Coupling | Description | OD (in) | Wt (lb/ft) | Grade | Top (MD ft) | Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|---|
| | Conductor Casing | 16.000 | 65.00 | | 0 | 85 | C |
| BTC | Surface Casing | 9.625 | 36.00 | J-55 | 0 | 1,500 | C |
| LTC | Production Casing | 5.500 | 20.00 | HCL-80 | 0 | 8,699 | C |
| VamTop or Equiv. | Production Casing | 5.500 | 20.00 | 13CR-80ksi | 8,699 | 8,922 | C |

**Casing Cement Summary**

| C | Date | No. Sx* | Csg. OD (in) | Top (MD ft) | Bottom (MD ft) | Memo | RL |
|---|---|---|---|---|---|---|---|
| | | 1,609 | 5.500 | 0 | 5,000 | Lead - Low Portland | C |
| | | 407 | 9.625 | 0 | 500 | Class C Cement to Surface , Lead | C |
| | | 56 | 16.000 | 0 | 85 | Cmt to surface | C |
| | | 815 | 9.625 | 500 | 1,500 | Class C Cement to Surface, Tail | C |
| | | 1,010 | 5.500 | 5,000 | 8,200 | Tail - Acid Resistant Proprietary | C |
| | | 198 | 5.500 | 8,200 | 8,922 | Acid Resistant Proprietary | C |

**Tools/Problems Summary**

| Date | Tool Type | OD (in) | ID (in) | Top (MD ft) | Bottom (MD ft) | RL |
|---|---|---|---|---|---|---|
| | DV Tool | | | 8,200 | | C |
| | Fib Op Cable | | | 0 | 8,922 | C |
| | Ext. Csg Gauges | | | 8,245 | 8,845 | C |

**Cement Plug Summary**

| C | Date | No. Sx* | OD (in) | Top (MD ft) | Bottom (MD ft) | Memo | RL |
|---|---|---|---|---|---|---|---|
| | | 21 | 5.500 | 0 | 200 | | C |
| | | 21 | 5.500 | 1,150 | 1,350 | | C |
| | | 21 | 5.500 | 1,350 | 1,550 | | C |
| | | 21 | 5.500 | 3,441 | 3,641 | | C |
| | | 21 | 5.500 | 6,041 | 6,241 | | C |
| | | 31 | 5.500 | 8,622 | 8,922 | | C |

*Cement yield of 1.2 cuft/sx is utilized here, cement yield is subject to adjustment

Figure 4.8—Proposed plug and abandon schematic for the Spirea M-1 well.

## 4.6 Post-Injection Site Care and Facility Closure Plan

This post-injection site care (PISC) and facility closure plan for the EWS Hub was prepared to meet the requirements of WYDEQ Chapter 24 **§24**. The plan describes various activities that would occur once injection has ceased and during the site closure—once it has been demonstrated that no additional monitoring is needed to ensure that $CO_2$ will not migrate outside of the Project site boundary. Additionally, the PISC and facility closure plan is designed to protect and ensure that no endangerment to people, wildlife, agriculture, and USDWs exists within the AoR. The current plume model scenarios indicate that the $CO_2$ plume will stabilize within the Project Site boundary within 10 years after injection ceases (see Figure 4.12 in Section 4.6.1). To be conservative, High Plains plans to conduct post-injection monitoring for 50 years after injection ceases to confirm that the model does not show a risk of migration to the USDW or beyond the Project Site boundary.

Once injection ceases, the injection well will be plugged per the plugging plan described in *Section 4.5*. Surface equipment will be removed except as needed for long-term monitoring. A final closure report will be submitted to document the final status of the well, the monitoring data, and the final plume model.

Post-injection site care shall continue at least until the criteria required by W.S. **§35-11-313(f)(vi)(F)** is met:

- Public notice and a public hearing if requested, for the release of bonds or the termination of insurance instruments not less than ten years after the date when all wells, excluding the monitoring well, have been appropriately plugged and abandoned;
- All subsurface operations and activities have ceased and all surface equipment and improvements have been removed or appropriately abandoned;
- Or so long as necessary to obtain a completion and release certificate from the Administrator, certifying that plume stabilization has been achieved without the use of control equipment—based on a minimum of three consecutive years of monitoring data; and
- All required monitoring and remediation shows that the $CO_2$ injected into the site will not harm or present a risk to human health, safety, or the environment.

### *4.6.1 Predicted Post-Injection Subsurface Conditions*

<u>Pre-Injection and Post-Injection Pressure Differential</u>

Figure 4.9 represents the expected pressure differential between pre-injection and post-injection pressures in the injection zone. The maximum injection pressure buildup is 1,391 psi. The same modeled pressure differential in Figure 4.9 is shown spatially in Figure 4.10 at four timesteps starting at the end of the injection phase and ending in 2105 at site closure (end of PISC). Results from the dynamic reservoir simulation show that at no point during the modeled timeframe does the increase in reservoir pressure exceed the critical pressure, and is discussed in greater detail in **Appendix B**. Figure 4.11 shows the extent of the $CO_2$ plume at the end of injection for each well and 50 years after the end of injection in the Spirea I-1 (2105), when the plume has stabilized.

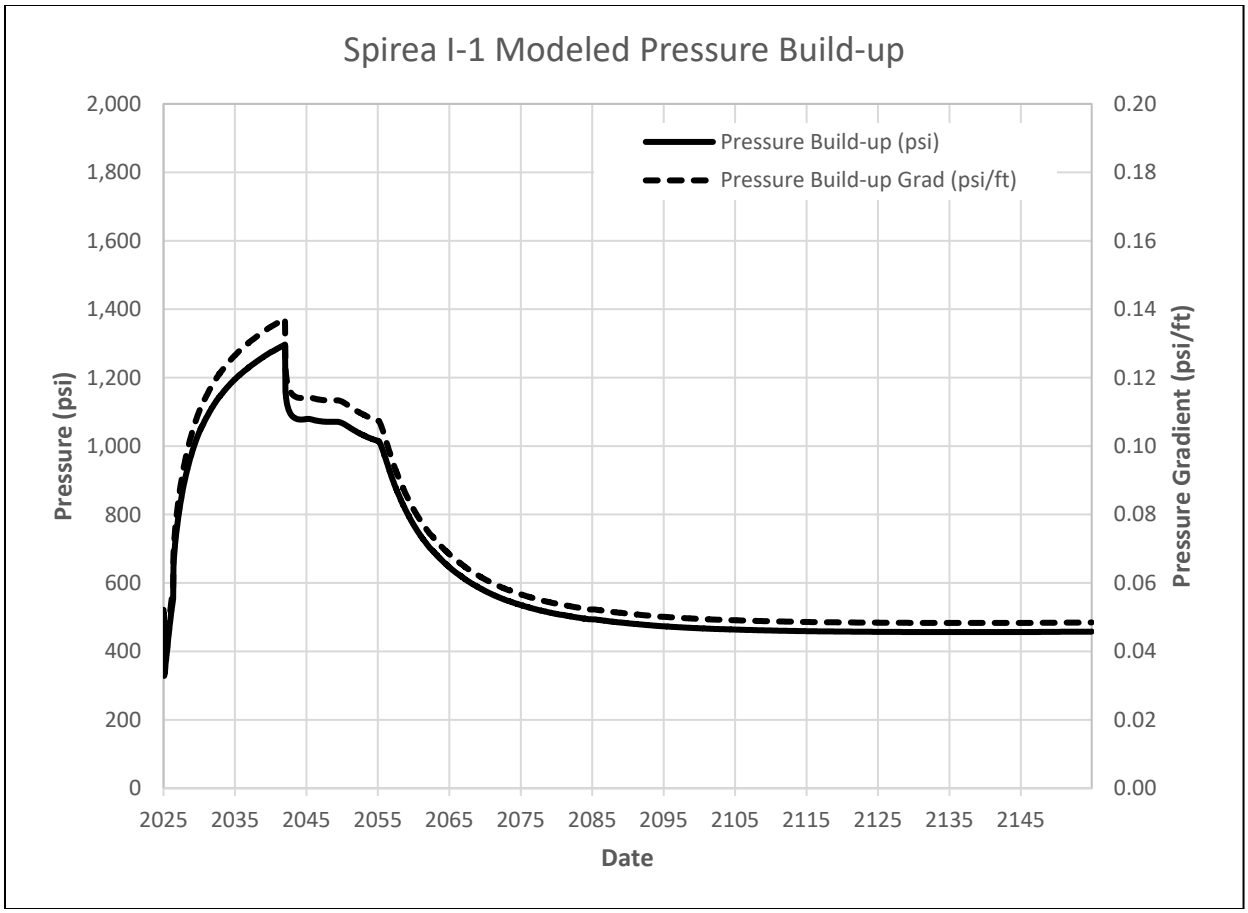



Figure 4.9—Predicted change in pressure in the storage reservoir more than 50 years following the cessation of $CO_2$ Injection.

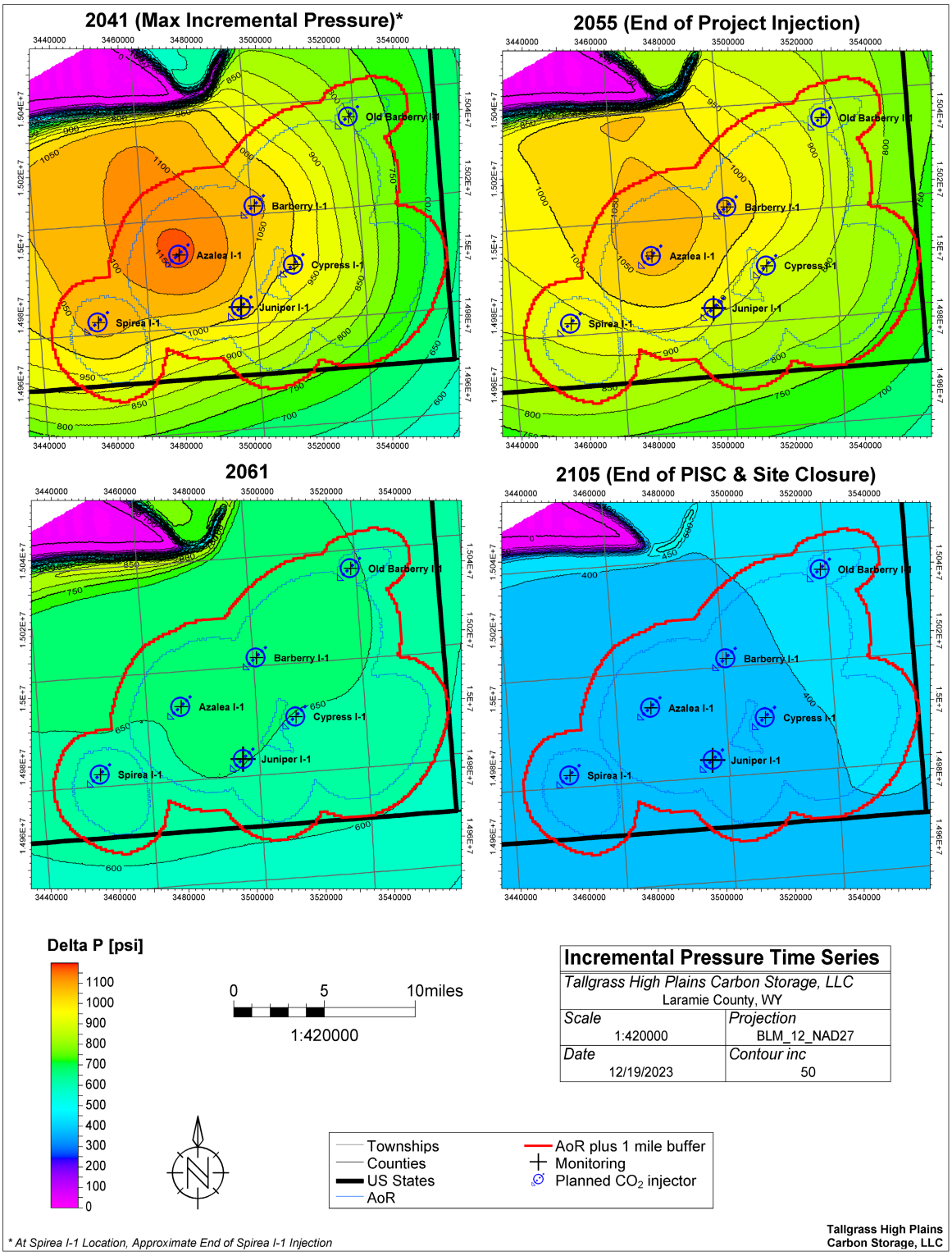



Figure 4.10—Incremental pressure (relative to pre-injection) time series for the Lyons Formation from the approximate end of injection in well Spirea I-1 (2041), the maximum incremental pressure at the well location, through site closure (2105). Following the end of injection, pressure begins to rapidly dissipate (ex. Pane 3—2061). Following this, pressure continues to fall. By 2105 (site closure), pressure at the Spirea I-1 location is modeled to be less than 375 psi above pre-injection levels—significantly below threshold (aka "critical") pressure that would be required to cause fluid migration into a USDW through a hypothetical artificial penetration.

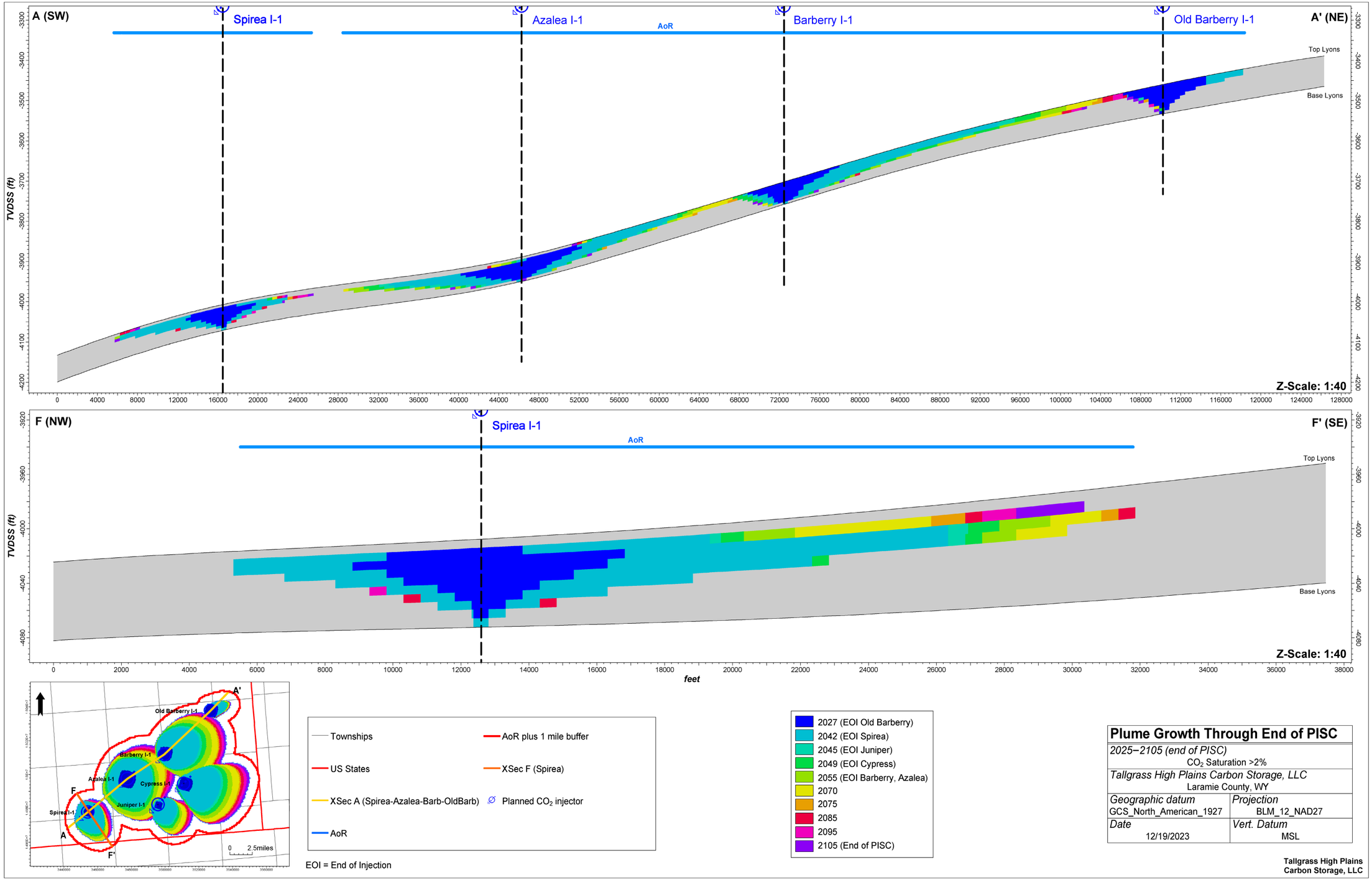



Figure 4.11—Map and cross sections through the simulation model at the location of the Spirea I-1 showing a time lapse of $CO_2$ plume distribution (>2% saturation) starting in 2027 (2 years after the start of injection), through site closure (2055).

Post injection, the percent change in plume radius can be seen in Figure 4.12. As the modeled time increases, the volume of mobile $CO_2$ is reduced, ultimately those volumes not trapped, by solubility, residual effects, or internal system stratigraphy become trapped against the caprock and continue to rise up-dip to the east-southeast driven by buoyancy. The volume of $CO_2$ trapped by relative permeability hysteresis was quantified using the relative permeability curves presented in the permit (Figure 3.18Figure 3.). Figure 4.12 demonstrates that in model year 2057, the percent change in the plume radius decreases to an average of 1% per year and continues to decrease through the end of the modeled timeframe. Cessation of the modeled plume migration is shown in the year 2105 when the change in radius is 0.1%.

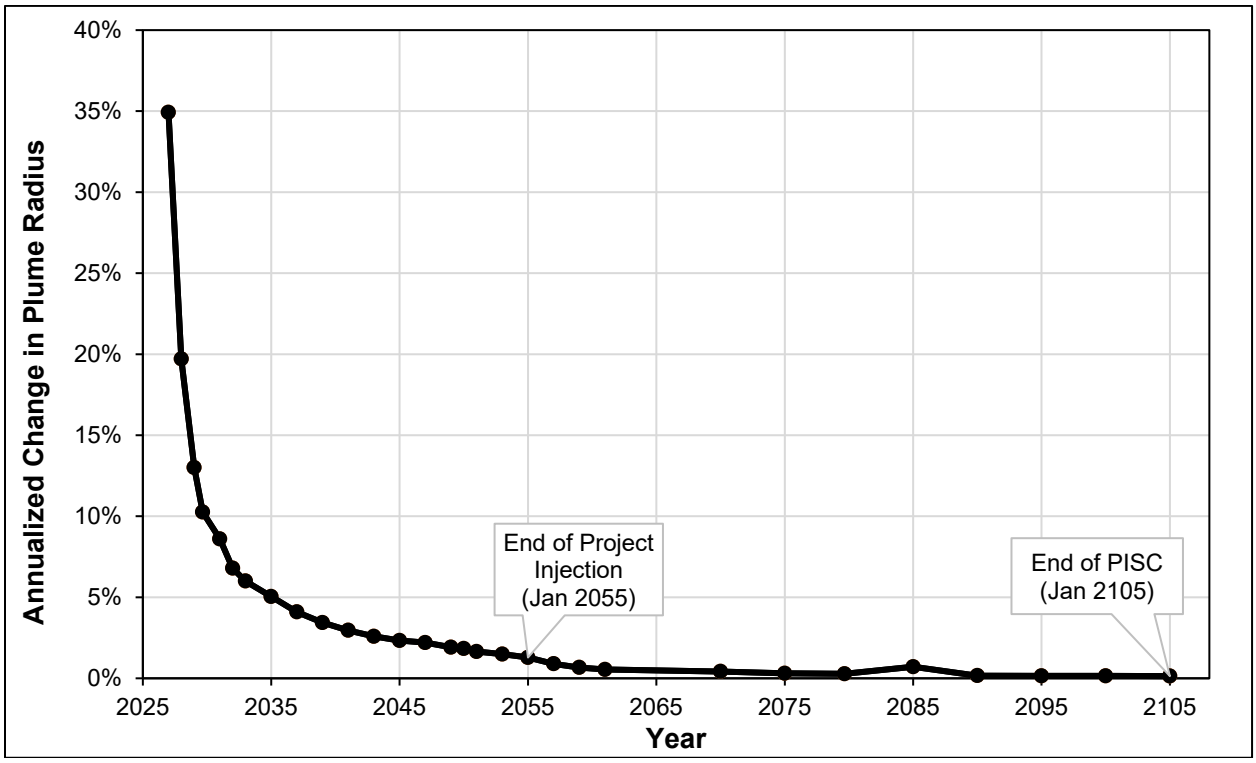



Figure 4.12—Annualized percent change in plume radius from the first year of injection through the end of post-injection site care (site closure). Utilizes the plume area with saturation greater than 2% and assumes the area is a circle.

The rate of $CO_2$ migration within the injection zone is primarily controlled by structural dip, facies, porosity and permeability distribution. A discussion of these geological properties and their adaptation and inclusion in the $CO_2$ plume modeling is included in the application narrative. Figure 4.14 shows the pressures and $CO_2$ plume at end of injection, through stabilization and the end of PISC.

The dominant trapping mechanisms that consume mobile volumes of $CO_2$ through the modeled timeframe are outlined. Site specific trapping mechanisms identified as having sufficient data to support being modeled and describe the distribution of trapped and supercritical $CO_2$ include structural, stratigraphic, residual, and solubility trapping. Structural and stratigraphic trapping mechanisms are incorporated into the dynamic simulation through the static model. The static geocellular model represents the facies distribution and couples the distribution of porosity and

permeability and shown in the porosity, permeability transform (Figure 4.15) to the dynamic simulation. In addition to the distribution of porosity and permeability, the dip of the injection zone impacts where buoyant and mobile volumes $CO_2$ will become trapped against low permeability baffles, or caprock as shown in Figure 4.11. As shown in Figure 4.16, the structural and stratigraphic trapping mechanisms used in the model have the greatest trapping contribution and are sufficient to hold the $CO_2$ in place indefinitely. Residual trapping as described by (Dongxiao Zhang 2014) accounts for those volumes of $CO_2$ which are immobilized by relative permeability hysteresis and shown in the drainage and imbibition curves, Figure 3.21 and the ratio of vertical permeability to horizontal permeability (kv/kh) applied in the dynamic model with a ratio of 0.1. Solubility trapping is incorporated into the dynamic simulation through Henry's law (Equation 4.1) and further refined by versions of Henry's constant correlations (Harvey 1996) to give improved results for $CO_2$.

Equation 4.1—Henry's Law

$$f = x * H$$

$$f = the\ fugacity\ of\ the\ compoent\ (bar)$$

$$x = composition\ of\ the\ component\ in\ the\ aqueosu\ phase$$

$$H = Henry's\ Law\ constant\ mol\ L^{-1}\ bar^{-1}$$

As shown in Figure 4.16, the contribution of solubility trapping increases through the modeled timeframe and has sufficient strength to hold $CO_2$ in place indefinitely. Mineral trapping as shown in Figure 4.16 has the lowest overall trapping contribution and least site-specific data from which to develop a model. For this reason, mineral trapping was not incorporated into the dynamic simulation.

At the end of the modeled timeframe (model year 2105), approximately 8.18 MMT of $CO_2$ is structurally trapped. Residual trapping stores 1.80 MMT. Solubility trapping accounts for approximately 0.61 MMT of $CO_2$ at the end of the model runtime. The modeled $CO_2$ fraction by phase is shown in Figure 4.13.

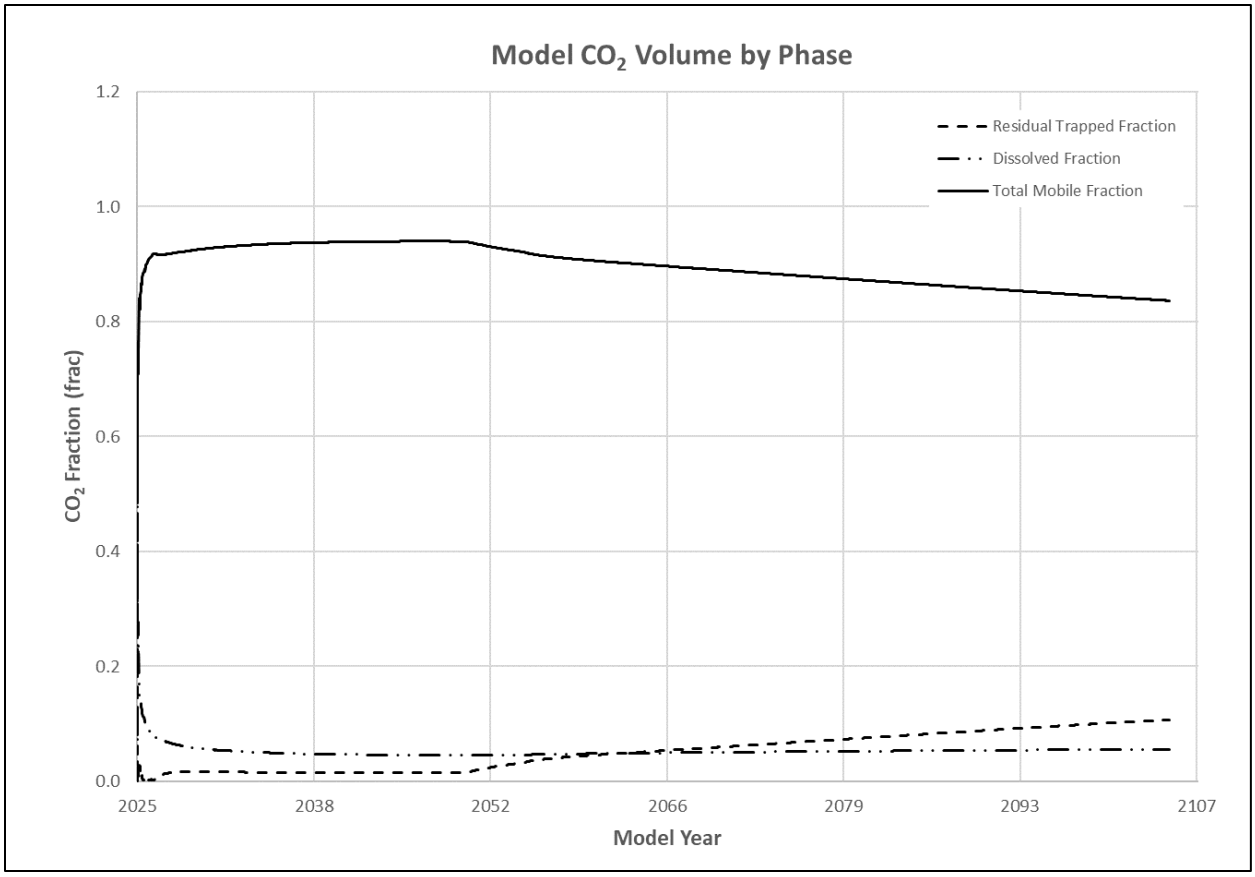


Figure 4.13—Modeled $CO_2$ fraction by phase.

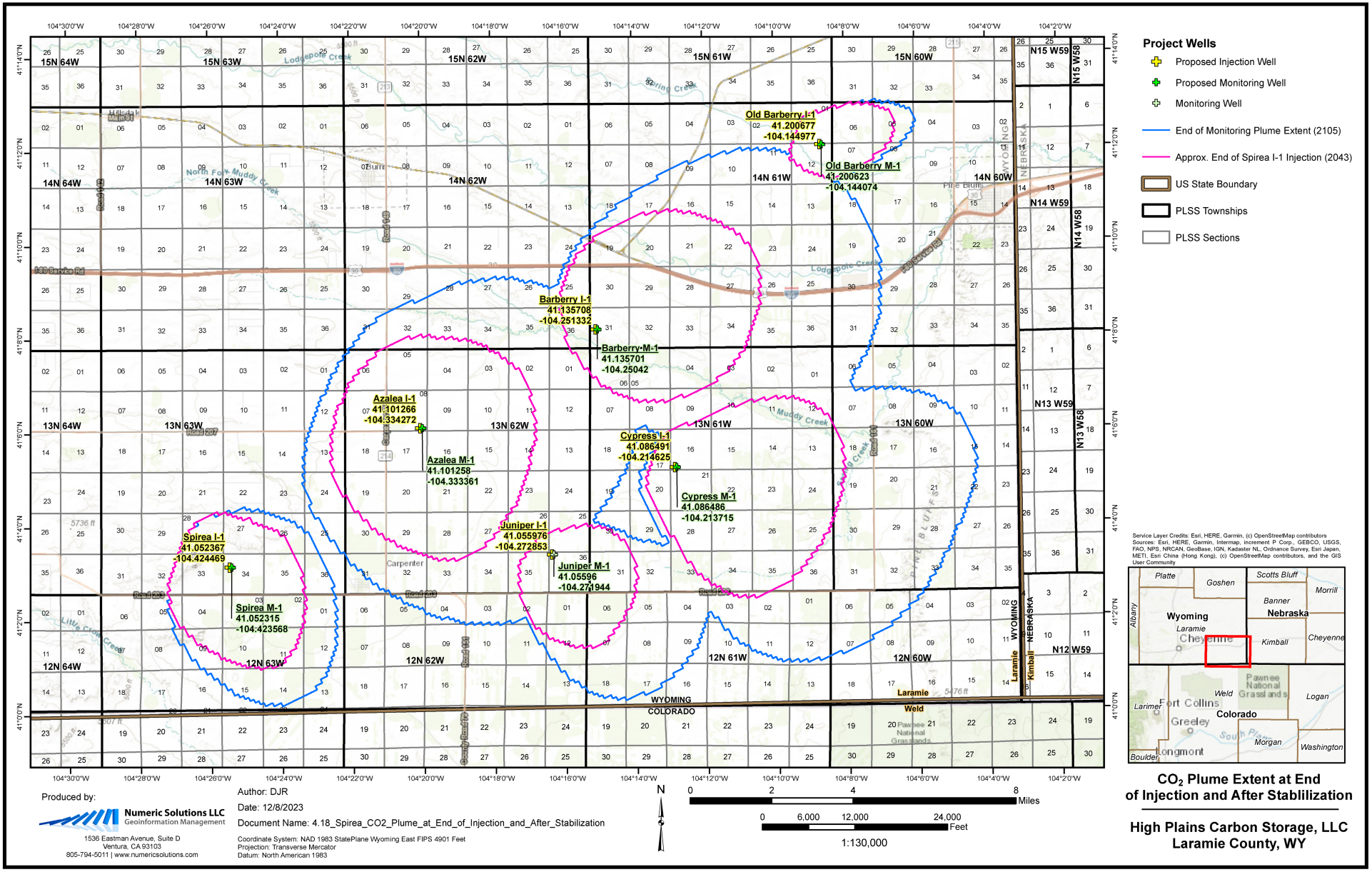



Figure 4.14—$CO_2$ plume at approximate end of injection (2043) in the Spirea I-1 well and at the end of PISC/site closure (2105).

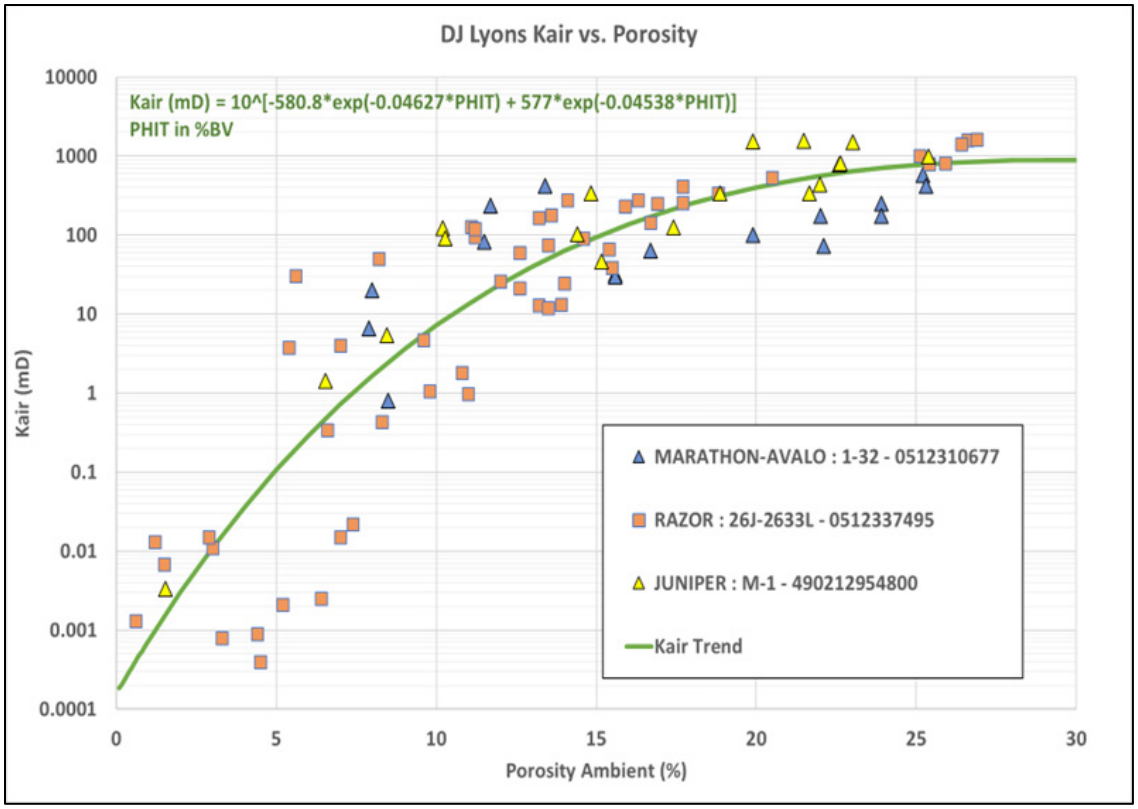



Figure 4.15—Porosity and permeability relationship.

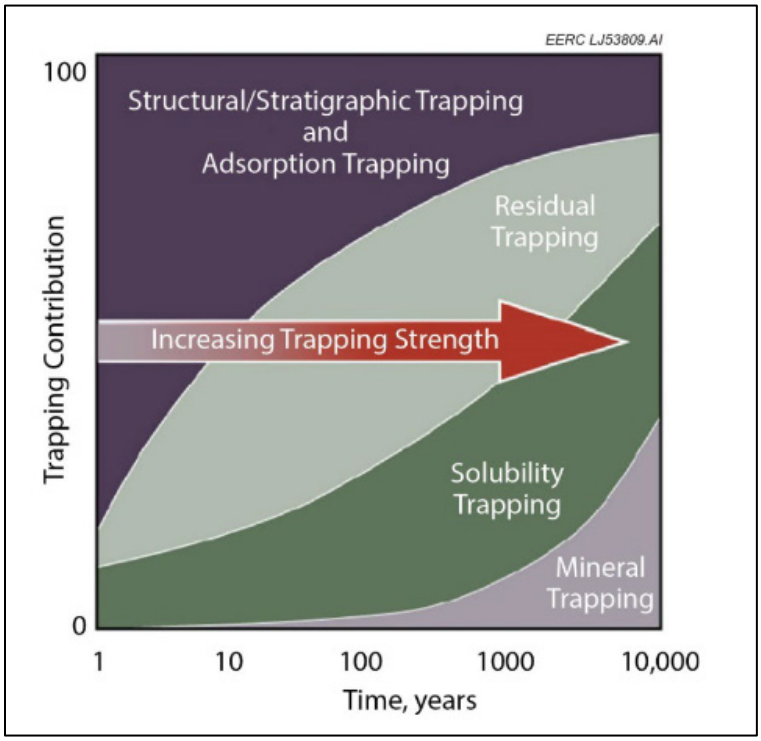



Figure 4.16—Trapping mechanisms by strength and contribution (Lu Jin et al. 2018, after Intergovernmental Panel on Climate Change 2005).

### *4.6.2 Post-Injection Monitoring Plan*

Table 4.29 summarizes the types and frequency of monitoring during PISC.

Table 4.29—Summary of post-injection site care monitoring program.

| Type of Monitoring | Frequency | Comments |
|---|---|---|
| **Near-Surface Monitoring** | | |
| Soil Gas | No proposed soil gas monitoring | Not applicable |
| Groundwater Wells | Annual | Using three shallow groundwater wells per injector. Until approved to cease monitoring. |
| Formation | Every five years | Lowermost USDW |
| **Storage Reservoir Monitoring** | | |
| Injection Well | Continuously using gauges | Until measurements indicate that plume has reached stabilization |
| **Downhole Monitoring (Injection Well and Monitoring Well(s)** | | |
| Downhole Pressure and Temperature Gauges; DTS (fiber optic cable) | Continuously | Until measurements indicate that plume has reached stabilization |
| **Geophysical Monitoring** | | |
| Time-Lapse 2D | Once | Confirm plume stabilization |

### *4.6.3 Groundwater and Soil Gas Monitoring*

High Plains plans to monitor shallow groundwater using three wells per injector, as outlined in Sections 4.3.5 and 4.3.7.

High Plains does not plan to monitor soil gas at this time as monitoring efforts in the first permeable layer above the confining zone and shallow groundwater sampling will identify leaks before a soil gas survey would.

### *4.6.4 Monitoring of $CO_2$ Plume and Pressure Front*

As indicated in Table 4.4, the $CO_2$ plume and pressure front will be monitored after injection activities cease. Reservoir temperatures and pressures will be measured in injection wells. The extent of the plume will indirectly be measured with time-lapse 2D surveys. Data gathered from these two methods during post-injection will be used to validate the predicted plume model. If data differs from the predicted behavior, the model will be updated.

### *4.6.5 Schedule for Submitting Post-Injection Monitoring Results*

All data and analysis gathered during PISC monitoring activities will be submitted to WYDEQ and the EPA annually, within 60 days of the anniversary of injection cessation. The reports will contain groundwater data, storage reservoir pressures and temperature, seismic data, and any reservoir-simulation results from new data.

These submitted monitoring reports will be used to serve as evidence to show that no additional monitoring is needed and that the EWS Hub does not—and is not expected to—endanger the USDW.

### *4.6.6 Site Closure Plan*

Site closure preparations will begin following immediately after PISC. The objective of the site closure plan is to ensure that all PISC monitoring wells are appropriately plugged, all records are maintained, and that future landowners are made aware of the project and previous land use.

As required by WYDEQ Chapter 24 **§24(b)(vi)**, High Plains will provide written notification to the Administrator at least 120 days before filing a request for site closure. If requested, the notification will provide a revised plan to include any changes that have been made since the original post-injection and site closure plan.

After the Administrator approves site closure, High Plains will plug and abandon the monitoring wells as described in *Section 4.5*. Surface facilities will be decommissioned and removed, and the surface restored as agreed to with the landowner.

### *4.6.7 Submission of Site Closure Report, Survey, and Deed*

A site closure report will be submitted to the Administrator within 90 days after completing all site closure activities. The report will include the following:

1. Documentation of injection and monitoring well-plugging that meets the requirements of WYDEQ Chapter 24 **§23** and **§24(c)**.
2. A copy of a survey plat that has been submitted to the local zoning authority designated by the Administrator.
    a. The plat will indicate the location of the injection well and monitoring wells relative to permanently surveyed benchmarks.
    b. A copy will also be submitted to the EPA Regional Administrator.
3. Documentation of appropriate notification and information to the state, local, and tribal authorities that have oversight of drilling activities, to enable them to impose appropriate conditions on subsequent drilling activities that may penetrate the injection and confining zone.
4. Proof that High Plains has
    a. Published notice of the application for site closure, including a mechanism to request a public hearing, in a newspaper of general circulation in each county of the proposed operation at weekly intervals for four consecutive weeks; and
    b. Mailed notice of the application for site closure to all surface owners, mineral claimants, mineral owners, lessees, and other owners of record of subsurface interests located within one mile of the proposed boundary of the geologic sequestration site.
5. Records of the carbon dioxide stream's nature, composition, and volume.

Lastly, High Plains will record a notation on the deed to the EWS Hub property or any document that is usually examined during the title search that will, in perpetuity, provide notice to any potential purchaser of the property. High Plains will also file an affidavit in accordance with W.S. **§35-11-313-(f)(vi)(G)** that will include the following information:

1. The subsurface pore space below the land has been used to sequester carbon dioxide;
2. The name of the state agency, local authority, or tribe to which the survey plat was filed, as well as the address of the EPA regional office to which it was submitted; and
3. The volume of fluid injected into the injection zone(s) and the time duration the injection occurred.

# 5 INJECTION WELL OPERATIONS

High Plains Spirea I-1 injection duration is dependent on the injection rate which may fluctuate but will not exceed the maximum injection rate of 4,101 Mt/day. Fluctuating injection rates yield an injection duration between five and 30 years while not extending the AoR. PISC remains 50 years post injection.

Pending the results of the reservoir quality testing program, completion techniques may be proposed to reduce skin and increase permeability. Proposed completion techniques will maintain seal integrity and may include perforation, acid, and stimulation. A stimulation program will be executed upon WYDEQ approval. An example of a mud acid work over is provided in Appendix J. Proposed stimulation techniques may be executed over the injection period of the project.

Table 5.1 provides the operating parameters and engineering criteria during injection operations required under WYDEQ Chapter 24 **§10.b.xvii**. Using these criteria, the injection well will be operated to prevent the migration of $CO_2$ to a USDW.

Table 5.1—Proposed injection well operating parameters.

| Item | Values | Description/Comments |
|---|---|---|
| Injected Volume | | |
| Total Injected Volume | 10.62 million metric tons | Based on expected injection |
| Injection Rates | | |
| Proposed Average Injection Rate | 1,656 MT/day | |
| Calculated Maximum Daily Injection Rate | 4,101 MT/day | Based on maximum surface injection pressure |
| Pressure | | |
| Formation Fracture Pressure at Top Perforation | 4,508 psi | Estimated formation fracture gradient of 0.57 psi/ft |
| Average Operating Surface Injection Pressure | 1,420 psi | Proposed average surface injection pressure |
| Surface Maximum Injection Pressure | 1,597 psi | Based on 90% of fracture gradient |
| Average Operating BHP | 4,210 psi | Expected average operating conditions |
| Maximum BHP | 4,509 psi | Based on 90% of fracture gradient |
| Tubing-Casing Annular Pressure | 1,520 psi | 100 psi above maximum surface injection pressure |

Per WYDEQ Chapter 24 **§18(d),** mechanical integrity will be maintained at all times, other than for workovers or maintenance.

Source of $CO_2$

The $CO_2$ to be injected will be sourced from ethanol plants, ammonia plants, and power plants then transported on the Trailblazer pipeline to Spirea I-1.

Table 5.2 shows the planned composition of the injectate stream, per the pipeline specifications:

Table 5.2—Composition of the injectate stream.

| Constituent | Limit |
|---|---|
| $CO_2$ | ≥ 95 mol% |
| CO | ≤ 0.4 mol% |
| $H_2$ | ≤ 0.5 mol% |
| $H_2S$ | ≤ 20 ppm |
| Total Sulfur | ≤ 35 ppm |
| Total $NO_x$ | ≤ 10 ppm |
| $O_2$ | ≤ 1 mol% |
| $H_2O$ | ≤ 150 ppm |
| Hydrocarbons | ≤ 4 mol % |
| Glycol | 0.3 gallons/MMCF |
| Maximum dew point at 400 psig | 30°F |
| Non-condensable gases | ≤ 5% mol% |

High Plains plans to inject 1.5 MMT/yr of $CO_2$ until the total volume to be injected is ±29 MMT. The maximum bottom hole injection pressure of 4,509 psi is less than 90% of the formation fracture gradient (4,846 psi) and therefore does not endanger USDWs. Per WYDEQ Chapter 24 **§18(b)**, $CO_2$ will not be injected in the surface to production casing annulus.

## 5.1 Proposed Completion Procedure to Conduct Operations

1. **Test Production Casing.**
    a. Fill production casing with brine or produced saltwater.
    b. Pressure casing to 1,000 psi, shut in well, and record pressures for at least 30 minutes.
    c. Contact the designated engineer and company representative if the casing drops more than 10%. Determine the cause of failure and perform corrections as needed.
2. **Run Cased Hole Logs.**
    a. Rig up wireline company and pressure test wireline lubricator.
    b. Run ultrasonic imaging tool and cement bond log /variable density log, casing collar locator, temperature-gamma ray log from total depth to surface.
    c. If cement evaluation logs indicate poor cement behind the production casing, notify the Administrator to develop a proposed action plan.
3. **Perforate Lyons Formation.**
    a. Perforate the injection zone. Company engineers and geologists will determine perforating zones within the Lyons, and final perforating gun selection after reviewing the open hole logs.
    b. Rig down wireline truck.
4. **Run Step-Rate Test.**
    a. Run in hole with retrievable packer and downhole gauge, then set at the top of the perforations.

b. Pressure test the packer to 1,000 psi for 15 minutes.
c. Perform step-rate test following the rates and times listed in Table 5.3.
d. Ensure that each step is held for the minimum time indicated, or until the pressure on the bottom hole gauge has stabilized, whichever is longer. All subsequent steps should be held for an equivalent time period.
e. After the last injection rate is reached, hold for the set time period. Then shut in and record the instant shut-in pressure (ISIP). Record the pressures after 5, 10, and 15 minutes.

**5. Stimulate Well.**

a. If indicated by the results of the injectivity (step-rate) test performed above, artificial stimulation techniques may be proposed to reduce skin and increase permeability. Proposed artificial stimulation techniques will maintain seal integrity and may include perforation, acid, and fracture stimulation. A stimulation program will be executed upon WYDEQ approval. An example of a mud acid stimulation procedure is provided in Appendix J. Proposed stimulation techniques may be executed over the injection period of the project.

**6. Rig Down.**

a. Release retrievable packer and pull out of hole.
b. Run in hole with 4 ½ in. tubing and completion assembly.
c. Circulate hole with corrosion inhibitor packer fluid.
d. Set the injection packer less than 100 ft above the top of the injection perforations.
e. Test annulus of tubing and casing to 1,000 psi.

Table 5.3—Proposed step-rate test.

| Step | Rate (bpm) | Time (min) | Volume (bbl) | Cumulative Volume (bbl) | Max. Tubing Pressure (psi) | Casing Pressure (psi) | Comments |
|---|---|---|---|---|---|---|---|
| 0 | 0.5 | 30 | 15.0 | 15.0 | | | |
| 1 | 2.6 | 30 | 78.0 | 93 | | | |
| 2 | 5.21 | 30 | 156.3 | 249.3 | | | |
| 3 | 10.42 | 30 | 312.6 | 561.9 | | | |
| 4 | 15.63 | 30 | 468.9 | 1,030.8 | | | |
| 5 | 20.83 | 30 | 624.9 | 1,655.7 | | | |
| 6 | 26.04 | 30 | 781.2 | 2,436.9 | | | |
| 7 | 31.25 | 30 | 937.5 | 3,374.4 | | | |
| 8 | 36.46 | 30 | 1,093.8 | 4,468.2 | | | |
| 9 | 41.67 | 30 | 1,250.1 | 5,718.3 | | | |
| 10 | 46.88 | 30 | 1,406.4 | 7,124.7 | | | |
| 11 | 52.08 | 30 | 1,562.4 | 8,687.1 | | | |
| 12 | 57.29 | 30 | 1,718.7 | 10,405.8 | | | |
| 13 | 62.5 | 30 | 1,875.0 | 12,280.8 | | | |
| 14 | 67.71 | 30 | 2,031.3 | 14,312.1 | | | |
| ISIP | | | | | | | Record ISIP |
| 5 min | | | | | | | Record 5-min SIP |
| 10 min | | | | | | | Record 10 min SIP |
| 15 min | | | | | | | Record 15-min SIP |
| Total | | 420 | 14,312.1 | 14,312.1 | | | |

Note: The maximum injection pressure will be established by the step-rate test (SRT) and is not to exceed 90% of formation fracture pressure. A temporary maximum surface injection pressure is issued until the SRT is conducted.

## 5.2 Proposed Procedure for Monitoring Well Operations

The Spirea M-1 well is located within the AoR and will monitor above the confining zone. Pressure and temperature gauges will be installed in the well via TEC. If the pressure or temperature gauges on the TEC are not adequate, new gauges would be run in the wellbore, either on the tubing or through tubing wireline as appropriate.

## 5.3 Operating Annular Pressure

The operating annular pressure between the tubing and casing will be limited to 100 psi over surface injection pressure. The maximum operating annular pressure will be 2,099 psi.

# APPENDIX A—RECORD OF PLUGGING AND COMPLETION

Three wells penetrate the confining zone within the area of review:

- Fritz 1 (49-021-05033)
- UPRR Palm 1-21 (49-021-20254)
- Juniper M-1 (49-021-29548)

The plugging and completion procedures for Fritz 1, and UPRR Palm 1-21 are attached to this application. The file names are:

- Fritz 1: **WELL HISTORY_API_49-021-05033_NAME_FRITZ 1.pdf**
- UPRR Palm 1-21: **WELL HISTORY_API_49-021-20254_NAME_UPRR PALM 1-21.pdf**

The Juniper M-1 completion and plugging procedures will be provided once the well is plugged back since it is still undergoing characterization.

May 5, 1954

C. V. Davis
Bank of Commerce Building
Sheridan, Wyoming

Re: $2500 Individual Well Bond
No. SA-189129
Ginther, Warren & Ginther
Well No. 1 Fritz
C SE NE Sec. 36-14-61

Dear Mr. Davis:

The above captioned well location has been inspected and found to be in good order, further, the operator has met the requirements of the Wyoming Oil and Gas Conservation Commission.

Therefore, you may consider this your authority to terminate the captioned bond, the effective date of termination to be February 3, 1954.

Very truly yours,

STATE MINERAL SUPERVISOR

By
K. E. Storms

KES/fo

cc: Ginther, Warren & Ginther
Box 769
Sterling, Colorado

Form No. 1

# STATE OF WYOMING
## Office of State Mineral Supervisor
COMMISSIONER OF PUBLIC LANDS
OIL AND GAS CONSERVATION DEPARTMENT
Casper, Wyoming

# SUNDRY NOTICES AND REPORT ON WELLS
Located on Patented and State Lands

| | | | |
|---|---|---|---|
| Notice of Intention to Drill | | Subsequent Report of Water Shut-Off | |
| Notice of Intention to Change Plans | | Subsequent Report of Shooting or Acidizing | |
| Notice of Intention to Test Water Shut-off | | Subsequent Report of Altering Casing | |
| Notice of Intention to Re-Drill or Repair Well | | Subsequent Report of Re-Drilling or Repair | |
| Notice of Intention to Shoot or Acidize | | Subsequent Report of Abandonment | X |
| Notice of Intention to Pull or Alter Casing | | Supplementary Well History | |
| Notice of Intention to Abandon Well | | | |

(Indicate Above by Check Mark Nature of Report, Notice, or Other Data)

The following is {notice of intention to do work / statement of work done} on {patented / State} land described as follows:

Tracy (Field) Laramie (County) E. Fritz (Farm)

Well No. 1 located on C SE ¼ NE ¼ of Section 36 Twp. 14 N Range 61 W Meridian.

and measures 660 ft. from (N)(S) line and 660 ft. from (E)(W) line of NE ¼ of the section.

The ground-elevation above sea level is 5198 ft. Height of ~~derrick floor~~ rotary bushing above ground 10 ft.

Details of Plan of Work: (State names of and expected depths to objective sands; show sizes, weights, and lengths of proposed casings; indicate mudding jobs, cementing points, and all other important proposed work, also point from which well measurements are taken, i.e., cellar, derrick floor or rotary bushing.)

Well had no shows of oil or gas. Notice of intention to abandon was given by telephone to Mr. Geo. W. Jarvis and permission received.
Placed cement plugs through drill pipe using Halliburton cementing truck to mix and displace the cement. Remainder of hole is full of 9½ lbs./gal 70 viscosity mud.
Placed plug opposite Lyons Sand 8775-8670 using approximately 45 sacks of oil well cement.
Placed plug opposite "J" sand 7625-7520 using approximately 47 sacks.
Placed plug at the base of surface casing. 350-300 with 25 sacks
Placed plug at top of surface casing using 15 sacks.
Location will be leveled and marker erected as soon as practical. See attached explanation.

5-27-53 No release or bond yet

1 APPROVALS SENT 5-27 1953

Held for [illegible]

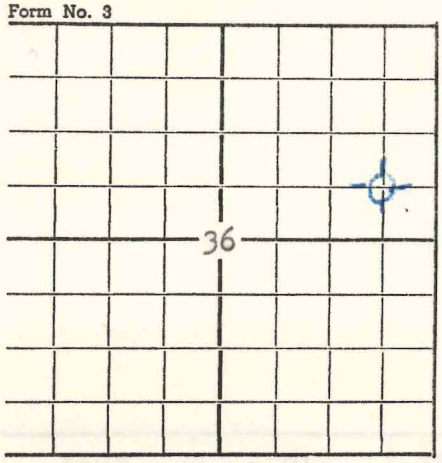
Approved: MAY 27 1953
Geo. W. Jarvis
State Mineral Supervisor.

Date May 7, 1953
Company Ginther, Warren & Ginther
By (Sign) R A Warren
Title Superintendent
Address Sterling, Colorado

Submit report of proposed work, for approval, on this form. In triplicate when located on State Land. In duplicate when on Patented Land.

(over)

Form No. 3




Locate Well Correctly

POSTED

STATE OF WYOMING
COMMISSIONER OF PUBLIC LANDS
OIL AND GAS CONSERVATION DEPARTMENT

**Office of State Mineral Supervisor**
CASPER, WYOMING

MINERAL SUPERVISOR OFFICE OF MAY 14 1953 RECEIVED

91-05033

# Log of Oil and Gas Well

The information given herewith is a complete and correct record of the well and all work done theron.

Operator Ginther, Warren & Ginther Address Box 769, Sterling, Colorado

State or Patented: if State—Lease No. ..... Field Tracy Area County Laramie

Land Owner E. Fritz Lessee .....

Well No. 1, ¼C-SE ¼ NE ¼ Sec. 36 T 14 N R 61 W Meridian 6

Location 660 ft. ~~N. of S.~~ Line and ..... ft. ~~E. of W.~~ Line of NE¼ of section 36
S. of N. W. of E.

Ground elevation of well 5198 Height of derrick floor, rotary bushing, above ground 10

All measurements from ground, derrick floor, rotary bushing. Signed R A Warren

Date May 1, 1953 Title Supt.

The summary on this page is for the condition of the well at the above date.

Commenced drilling February 29, 19 53 Finished drilling April 12, 19 53

## OIL AND GAS, SANDS OR ZONES
(Note producing sand)

No. 1, from ..... to ..... No. 4, from ..... to .....

No. 2, from ..... to ..... No. 5, from ..... to .....

No. 3, from ..... to ..... No. 6, from ..... to .....

## WATER SANDS

No. 1, from ..... to ..... No. 3, from ..... to .....

No. 2, from ..... to ..... No. 4, from ..... to .....

## CASING RECORD

| Size | Wgt. Per Ft. | Grade | Make | Amt. | Kind of Shoe | Cut and Pulled from | Perforated From | Perforated To | Purpose |
|---|---|---|---|---|---|---|---|---|---|
| 10-3/4 | 32.75 | J55 | | | Guide | | | | Surface |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

## CASING MUDDING AND CEMENTING

| Size | Where Set | Amount of Cement or Mud | Company | Mud Weight | Amount of Put Away |
|---|---|---|---|---|---|
| 10-3/4 | 324 | 175 Sax | Halliburton | | |
| | | | | | |
| | | | | | |
| | | | | | |

## ACIDIZING OR SHOOTING RECORD

| | | Kind Explosive or | | | |
|---|---|---|---|---|---|

Corporate Surety Bond

**STATE OF WYOMING**

**WYOMING OIL AND GAS CONSERVATION COMMISSION**

# OWNER'S WELL PLUGGING AND REPAIR BOND

KNOW ALL MEN BY THESE PRESENTS, that we N. C. GINTHER, H. C. WARREN and W. L. GINTHER, co-owners, as principal, and INDEMNITY INSURANCE COMPANY OF NORTH AMERICA, a surety company authorized to do business in the State of Wyoming, as surety, are held and firmly bound unto the State of Wyoming in the sum of Two Thousand Five Hundred and no/100 - - - - - - - - - Dollars ($2,500.00) lawful money of the United States, to be paid to the Wyoming Oil and Gas Conservation Commission, as agent of the State of Wyoming, for the use and benefit of the State of Wyoming, for which payment well and truly to be made, we bind ourselves, our heirs, executors and successors, jointly and severally by these presents.

THE CONDITION OF THE OBLIGATION IS SUCH THAT,

WHEREAS, the principal is about to commence operations for oil or gas in the State of Wyoming which operation is to consist of drilling, redrilling, deepening, plugging and abandoning, and the production of oil and gas, which operations are subject to the jurisdiction and control of the Wyoming Oil and Gas Conservation Commission and:

WHEREAS, the aforesaid operations are to be performed on WELL NO. 1 E. Fritz, located 660 feet from suth line and 660 feet from E line of NE¼ ¼ ¼, SECTION 36, TOWNSHIP 14N NORTH, RANGE 61 West WEST, LARAMIE COUNTY, WYOMING on land under lease from EARL FRITZ ET UX lessor.

NOW, THEREFORE, if said N. C. Ginther, N. C. Warren and W. L. Ginther, co-owners, the above bounden principal, shall well and truly comply with all the provisions of Chapter 94, Session Laws of Wyoming, 1951, and the rules, regulations, and requirements of the Wyoming Oil and Gas Conservation Commission made pursuant thereto, and the orders of the State Mineral Supervisor or his assistants, with reference to the properly plugging of said well or repair of said well, if causing waste, then this obligation shall be void; otherwise, it shall remain in full force and effect.

IN WITNESS WHEREOF, we have hereunder set our respective hands and seals this 3rd day of February, A. D., 1953.

*Witness*

N. C. Ginther

H. C. Warren (SEAL)

*ATTEST:*

W. L. Ginther

*Principal*

6

May 5, 1953

Ginther, Warren & Ginther
P. O. Box 769
Sterling, Colorado

Re: Well No. 1 Fritz
SE NE Sec. 36-14-61
Tracy Field
Laramie County, Wyoming

Gentlemen:

On February 13, 1953 this office approved the Notice of Intention to Drill the subject well. Since that time no further notices, reports, or logs have been received by this office. Now, we understand, the well has been plugged and abandoned and done so without the approval of this office. This contrary to the Wyoming Oil and Gas Conservation Commission Rules and Regulations.

For your information I am enclosing a copy of said Rules and Regulations and have checked rules which pertain to plugging and abandoning wells. Familiarization with Wyoming laws and the Rules and Regulations promulgated by the Commission will elimate much needless confusion and correspondence.

We shall expect, in the very near future, to receive all applicable notices and reports as well as two copies of the formation and electric logs. May we suggest that on future operations in Wyoming it would be to the advantage of Ginther, Warren and Ginther if they cooperated more closely with this office.

Very truly yours,

Kenneth G. Lloyd
Assistant State Mineral Supervisor

KGL/fo
Encl./ Copy of Rules and Regulations
Form 1's and formation log forms.

| Date | Company | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

## TOOLS USED

Rotary tools used from 0 feet to T.D. feet, and from ..... feet to ..... feet

Cables tools were used from ..... feet to ..... feet, and from ..... feet to ..... feet

## DATES

Completed April 18, 19 53 Put to producing ....., 19.....

The production for the first 24 hours was ..... barrels of fluid of which .....% was oil, .....% emulsion; .....% water. Gravity °Be, .....

The production for the first 24 hours after acidizing, shooting was ..... barrels of fluid of which .....% was oil .....% emulsion; .....% water.

If gas well, cu. ft. per 24 hours ..... Gallons gasoline per 1,000 cu. ft. of gas .....

Rock pressure, lbs. per sq. in. ..... Hydrogen sulphide per 100 cu. ft. of gas .....

Method of obtaining production .....

Name of Contractor Sterling Drilling Company

..... Driller ..... Driller

..... Driller ..... Driller

## FORMATION RECORD

Make note of depths from which cores were taken, and Recovery

(Note all formation tops)

| | FROM | TO | THICKNESS | FORMATION |
|---|---|---|---|---|
| | 0 | 912 | 912 | Tertiary & Laramie |
| | 912 | 4120 | 3208 | Pierre Sh |
| | 4120 | 4355 | 235 | Hygiene S.S. & S. sh |
| Cor# #1 | 4280 | 4312 | 32 | Recovered 31-3/4' Hard tight sandy shale. DST 4280-4320 - Open 1 hr. Shut in 15 minutes - Recovered 3060' water |
| | 4335 | 6605 | 2270 | Pierre Shale |
| | 6605 | 6935 | 330 | Niobrara (Timpas LS @ 6825) |
| | 6935 | 7195 | 260 | Carlile Sl |
| | 7195 | 7287 | 92 | Greenhorn L.S. |
| | 7287 | 7422 | 135 | Grenaros Sl |
| | 7422 | 7434 | 12 | "D" Sand |

Oil City Printers—Casper

(OVER)

SCALED

2




This location is on a hillside directly above a grain field. Attempting to fill the pits and level the location at the present time would cause mud to run down the hill onto this field with probable damage to the crop.

A stout fence has been erected completely encircling the pits to protect the land owners livestock.

When the crop has been harvested and the mud in the pits has been dried out, we will remove the fence and clean up this location and place a marker flush with the ground.

# Verbal Approval For Well Abandonment

Date 11-2-81 Time 4:00 A.M. P.M.

Operator TRANS Texas.

Representative Dick Parker

Well Name and No. TRANS Texas Energy 1-21 UPRR - Palm

Located ¼ SE ¼ SW ¼ Sec. 21 Twp. 13 Range 62

Field W.C County Laramie

## Plugging Data

Total Depth 9420 Size Hole 7 7/8. Mud Weight 9.0 ppg

Surface Casing; Size 9 5/8 Depth 403' K.B.

| FORMATION TOP (In Feet) | | PLUGS From | To | Sax Cement |
|---|---|---|---|---|
| Fox hills | 1200' | 9280 | 9380 | 35 sk |
| Hy O Sand | 2010-2025 | 6780 | 6880 | 35 sk |
| Suxvey | 3750 | 4780 | 4880 | 35 sk |
| Base " | 3913 | 2150 | 1950 | 50 sk |
| Shannon | 4388 | 350 | 450 | 35 sk |
| Base " | 4632 | Dry hole | Marker | 10 sk |
| Niobrara | 7184 | | | |
| Farthays | 7467 | | | |
| Codell | 7453 | | | |
| Green horn | 8210 | | | |
| ~~X Bent~~ | ~~7860~~ | | | |
| Mowry silt | 8007 | | | |
| Tight J silt | 8068 | | | |
| J Sand | 8106 | | | |
| Skullerk | 8177 | | | |
| Tight Dakota silt | 8305 | | | |
| " " sand | 8348 | | | |
| Morrison | 8549 | | | |

REMARKS Orbit Rig #7

Approved By Rich Marvel

Form 4
(June, 1975)

# STATE OF WYOMING
## OIL AND GAS CONSERVATION COMMISSION
### Office of State Oil and Gas Supervisor
### P. O. Box 2640
### Casper, Wyoming 82601

5. State Lease No. N/A

6. Unit Agreement N/A

7. Farm or Lease Name UPRR-Palm

8. Well No. 1-21

9. Reservoir N/A

10. Field Name N/A

11. Section, Township and Range Sec 21-13N-62W

1. SUNDRY NOTICES AND REPORTS ON WELLS

(Do not use this form for proposals to drill, deepen, or plug-back. Form 1 is provided for such proposals.)

OIL WELL ☐ GAS WELL ☐ OTHER DRY ☒

2. OPERATOR Trans-Texas Energy, Inc. 303-825-1577

3. ADDRESS 1801 Broadway, Suite 1420, Denver, Colorado 80202

4. LOCATION (Show quarter-quarter description and footage measurements. See also space 16 below)
At surface 1980' FWL 660' FSL in SE/4 SW/4

| 14. ELEVATIONS Derrick Floor | Rotary Kelly Bushing | Rotary Table | Ground | Other | 12. County | 13. State |
|---|---|---|---|---|---|---|
| 5430 | | | 5418 | | Laramie | Wyo |

15. INDICATE BELOW BY CHECK MARK NATURE OF REPORT, NOTICE OR OTHER DATA

| NOTICE OF INTENTION TO: (Submit in triplicate) | | | | SUBSEQUENT REPORT OF: (Submit in duplicate, triplicate on state lands) | | | |
|---|---|---|---|---|---|---|---|
| Test Water Shut-Off | ☐ | Pull or Alter Casing | ☐ | Water Shut-Off | ☐ | Repairing Well | ☐ |
| Fracture Treat | ☐ | Recomplete | ☐ | Fracture Treatment | ☐ | Altering Casing | ☐ |
| Shoot or Acidize | ☐ | Abandon | ☒ | Shooting or Acidizing | ☐ | Abandonment (Submit in triplicate) | ☐ |
| Repair Well | ☐ | Change Plans | ☐ | | | | ☐ |
| | | | ☐ | | | | |

(Note: Report results of multiple completion on Well Completion or Recompletion and Log form.)

16. DESCRIBE PROPOSED OR COMPLETED OPERATIONS. Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally drilled, give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.

Well plugged 11-3-81

| | |
|---|---|
| 15 sk | 30' |
| 35 sk | 403' |
| 50 sk | 2150' |
| 35 sk | 4880' |
| 35 sk | 6880' |
| 35 sk | 9380' |

Certificate attached.

RECEIVED
DEC 10 1981
WYOMING OIL & GAS
CONSERVATION COMMISSION

17. I hereby certify that the foregoing as to any work or operation performed is a true and correct report of such work or operations.

SIGNED Linda K Fyatt TITLE Exploration Technician DATE 12-7-81

(This space for State office use)

APPROVAL DATE JAN 8 1982

APPROVED BY (For) C. W. Farmer
State Oil and Gas Supervisor

2 Approvals sent JAN 8 1982 196

CONDITIONS OF APPROVAL, IF ANY

PLEASE FILE SUBSEQUENT REPORT OF ABANDONMENT (SRA) ON FORM 4 WHEN SITE HAS BEEN REHABILITATED AND IS READY FOR INSPECTION BY THE WOGCC.

CHAIRMAN
GOVERNOR ED HERSCHLER

# The State of Wyoming

STATE OIL AND GAS SUPERVISOR
DONALD B. BASKO

COMMISSIONERS
OSCAR E. SWAN
BERN WHITTAKER
RICHARD S. CROSS
DANIEL N. MILLER, JR.

BEST COPY AVAILABLE

OFFICE OF
OIL AND GAS CONSERVATION COMMISSION
STATE OIL AND GAS SUPERVISOR
123 SOUTH DURBIN
P. O. BOX 2640
CASPER
82602

EX OFFICIO DIRECTOR OF
OIL AND GAS CONSERVATION

(6)

## STATE OF WYOMING INSPECTION REPORT

Date 6/7/82 Time 6:50 P.M RECOMMEND RELEASE: By [signature]

Operator TRANS-TEXAS ENERGY

Field WILDCAT County LARAMIE Farm UPRR-PALM

Well No. 1-21 Loc. ¼ SE ¼ SW ¼ Section 21 T. 13N R. 62W

And measures ~~1980~~ 660 Ft. from (N) (S) L. and 1980 Ft. from (E) (W) Line

Ground elev. 5418 Drilling Contractor ORBIT DRILLING CO.

Surface Csg.: Size 9 5/8 " Amount 403 Total depth _____ PB Depth _____

Prod. Formation — From — to —

### DRY HOLE DATA

gulation Marker Erected Below Plow Depth Pits Filled Yes Cellar Filled Yes

Seeded Cultivated Field Condition of Location OK

### REMARKS

NID Recieved 10-9-81
FORM LOG Recieved 1-4-82
ELEC LOG Recieved 12-4-81

VERBAL APP. Given _____
NIA Recieved 1-4-82
SRA Recieved 1-4-82

Form 4
(June, 1975)

**STATE OF WYOMING**
**OIL AND GAS CONSERVATION COMMISSION**
**Office of State Oil and Gas Supervisor**
**P. O. Box 2640**
**Casper, Wyoming 82601**

5. State Lease No.: N/A

6. Unit Agreement: N/A

7. Farm or Lease Name: UPRR-Palm

8. Well No.: 1-21

9. Reservoir: N/A

10. Field Name: N/A

11. Section, Township and Range: Sec. 21-13N-62W

1. # SUNDRY NOTICES AND REPORTS ON WELLS

(Do not use this form for proposals to drill, deepen, or plug-back. Form 1 is provided for such proposals.)

OIL WELL ☐ GAS WELL ☐ OTHER DRY ☒

2. OPERATOR: Trans-Texas Energy 303-825-1577

3. ADDRESS: 1801 Broadway Suite 1420 Denver, Co./80202

4. LOCATION (Show quarter-quarter description and footage measurements. See also space 16 below)
At surface: 1980' FWL 660' FSL
SE SW Sec. 21-13N-62W
Laramie County, Wy.

12. County: Laramie

13. State: Wy.

14. ELEVATIONS

| Derrick Floor | Rotary Kelly Bushing | Rotary Table | Ground | Other |
|---|---|---|---|---|
| 5430 | | | 5418 | |

15. INDICATE BELOW BY CHECK MARK NATURE OF REPORT, NOTICE OR OTHER DATA

| NOTICE OF INTENTION TO: (Submit in triplicate) | | | | SUBSEQUENT REPORT OF: (Submit in duplicate, triplicate on state lands) | | | |
|---|---|---|---|---|---|---|---|
| Test Water Shut-Off | ☐ | Pull or Alter Casing | ☐ | Water Shut-Off | ☐ | Repairing Well | ☐ |
| Fracture Treat | ☐ | Recomplete | ☐ | Fracture Treatment | ☐ | Altering Casing | ☐ |
| Shoot or Acidize | ☐ | Abandon | ☐ | Shooting or Acidizing | ☐ | Abandonment (Submit in triplicate) | ☒ |
| Repair Well | ☐ | Change Plans | ☐ | | | | ☐ |
| | | | ☐ | | | | |

(Note: Report results of multiple completion on Well Completion or Recompletion and Log form.)

16. DESCRIBE PROPOSED OR COMPLETED OPERATIONS. Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally drilled, give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.

Well site plugged and abandoned 11/3/81 and is ready for inspection.
All other forms-Form #3, and NIT were previously sent to you with the plugging certificate.

Date plugged 11/3/81
15 SK 30'
35 SK 403'
50 Sk 2150'
35 SK 4880'
35 SK 6880'
35 SK 9380'

RECEIVED
DEC 2 1982
WYOMING OIL & GAS CONSERVATION COMMISSION

17. I hereby certify that the foregoing as to any work or operation performed is a true and correct report of such work or operations.

SIGNED Andrew K. Pratt TITLE Exploration Technician DATE 12-2-81

(This space for State office use)

APPROVAL DATE JUN 18 1982

APPROVED BY (for) C. W. Farmer
State Oil and Gas Supervisor

JUN 18 1982

Approvals sent 196

CONDITIONS OF APPROVAL, IF ANY

* See Instructions On Reverse Side

## INSTRUCTIONS

Proposals to abandon a well and subsequent reports of abandonment should include such special information as is required by local Federal and/or State offices. In addition, such proposals and reports should include reasons for the abandonment; data on any former or present productive zones, or other zones with present significant fluid contents not sealed off by cement or otherwise; depths (top and bottom) and method of placement of cement plugs; mud of other material placed below, between and above plugs; amount, size, method of parting of any casing, linear or tubing pulled and the depth to top of any left in the hole; method of closing top of well; and date well site conditioned for final inspection looking to approval of the abandonment.

Space 4: If there are no applicable State requirements, locations on Federal or Indian land should be described in accordance with Federal requirements.

## AFFIDAVIT OF PLUGGING

State of ~~XXXXXXXX~~ Nebraska
County of Kimball } ss.

Before me, Norma J. Nelson, a Notary Public in and for the said County and State, this day personally appeared W.R. Nelson, who being first duly sworn, deposes and says that he is employed by Orbit Drilling, Inc. as V/Pres of Drilling Operations in charge of well plugging in the _____ field; that he has read over and subscribed the foregoing well abandoning and plugging operations and the statements contained therein are true.

W.R. Nelson

Subscribed in my presence and sworn to before me this 20 th day of November, 19 81

Norma J. Nelson
Notary Public.

My Commission expires Feb. 5 , 1984

GENERAL NOTARY - State of Nebraska
NORMA J. NELSON
My Comm. Exp. Feb. 5, 1984

# APPENDIX B—DATA, PROCESSING, AND OUTCOMES OF $CO_2$ STORAGE GEOMODELING AND SIMULATIONS

# Appendix B—Data, Processing, and Outcomes of $CO_2$ Storage Geomodeling and Simulations

**Eastern Wyoming Sequestration Hub**

**Spirea I-1**

**Permit No. 2023-041**

**Facility ID No. WYS-021-00155**

**DECEMBER 2023**

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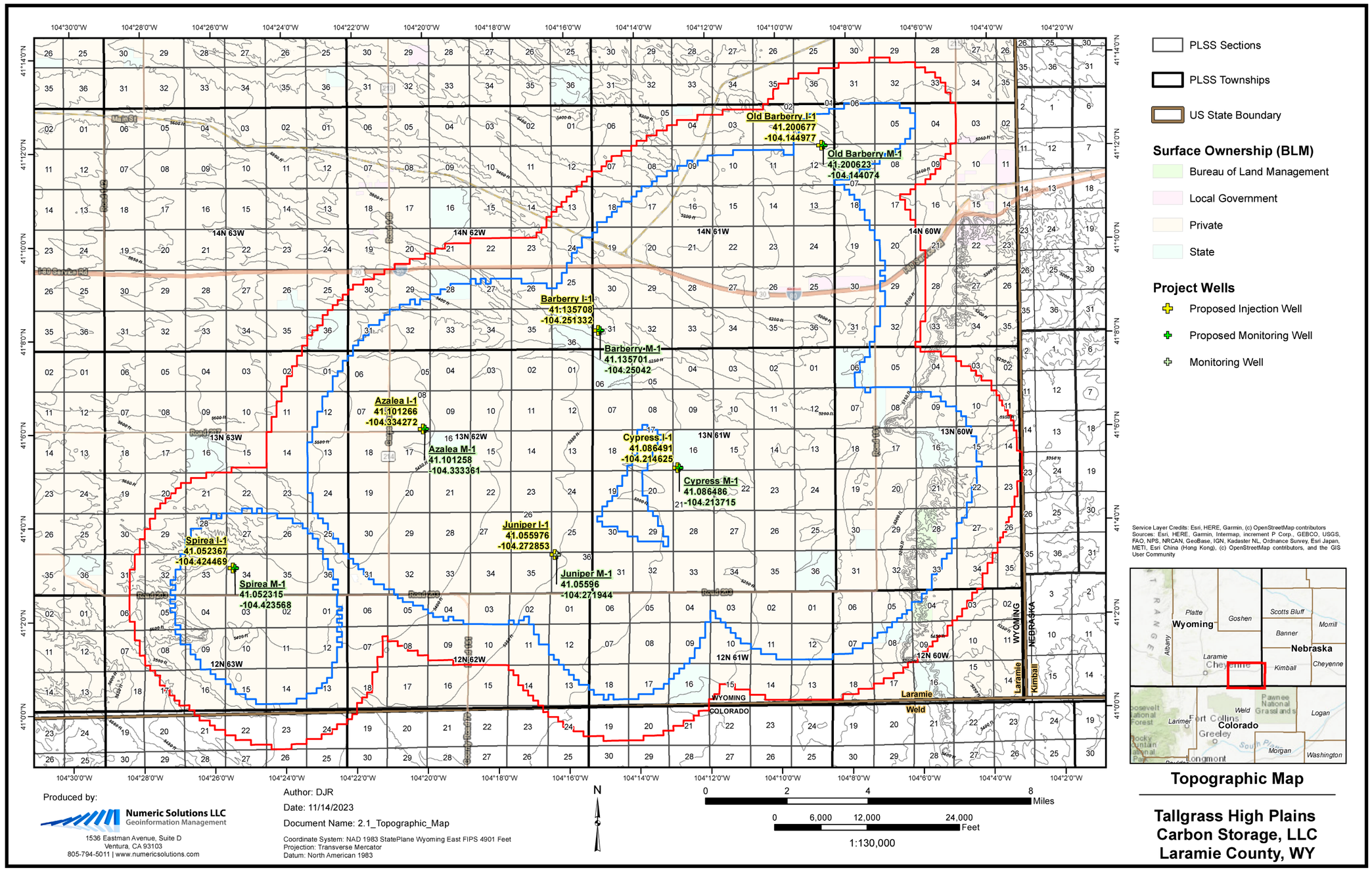
# B Data, Processing, and Outcomes of $CO_2$ Storage Geomodeling and Simulations

## B.1 Introduction

The Tallgrass High Plains Carbon Storage, LLC (High Plains) Eastern Wyoming Sequestration Hub (EWS Hub) is located in the southeastern corner of Laramie County, Wyoming. The EWS Hub is comprised of six safe carbon sequestration wells. The focus of this application is the Spirea I-1 (or "Project"), located in the north central portion of the Hub (Figure B.1, Figure B.2). A comprehensive geologic model and dynamic simulation were developed to assess the subsurface impact of injecting the proposed ±10.6 million metric tons (MMT) of supercritical $CO_2$ over a 18-year period. The modeling tasks aimed to calculate essential parameters, including changes in reservoir pressure, $CO_2$ saturation, and the impact of existing offset saltwater disposal operations in the region. These subsurface parameters provide critical insights across the Project Area and help delineate the Project's area of review (AoR). The model primarily consists of two confining zones and an injection zone. The Chugwater and Goose Egg formations have been identified as the upper seal, the Satanka as the lower seal, and the Lyons Formation as the injection zone.


Old Barberry I-1
41.200677
-104.144977
Old Barberry M-1
41.200623
-104.144074
Barberry I-1
41.135708
-104.251332
Barberry M-1
41.135701
-104.25042
Azalea I-1
41.101266
-104.334272
Azalea M-1
41.101258
-104.333361
Cypress I-1
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-104.214625
Cypress M-1
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-104.213715
Juniper I-1
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-104.272853
Juniper M-1
41.05596
-104.271944
Spirea I-1
41.052367
-104.424469
Spirea M-1
41.052315
-104.423568
14N 63W
14N 62W
14N 61W
14N 60W
13N 63W
13N 62W
13N 61W
13N 60W
12N 63W
12N 62W
12N 61W
12N 60W
WYOMING
COLORADO
NEBRASKA
Laramie
Weld
Kimball
I-80 Service Rd
Road 142
Road 144
Road 146
Road 148
Road 150
Road 152
Road 154
Road 156
Road 158
Road 160
Road 162
Road 164
Road 166
Road 168
Road 170
Road 172
Road 174
Road 176
Road 178
Road 180
Road

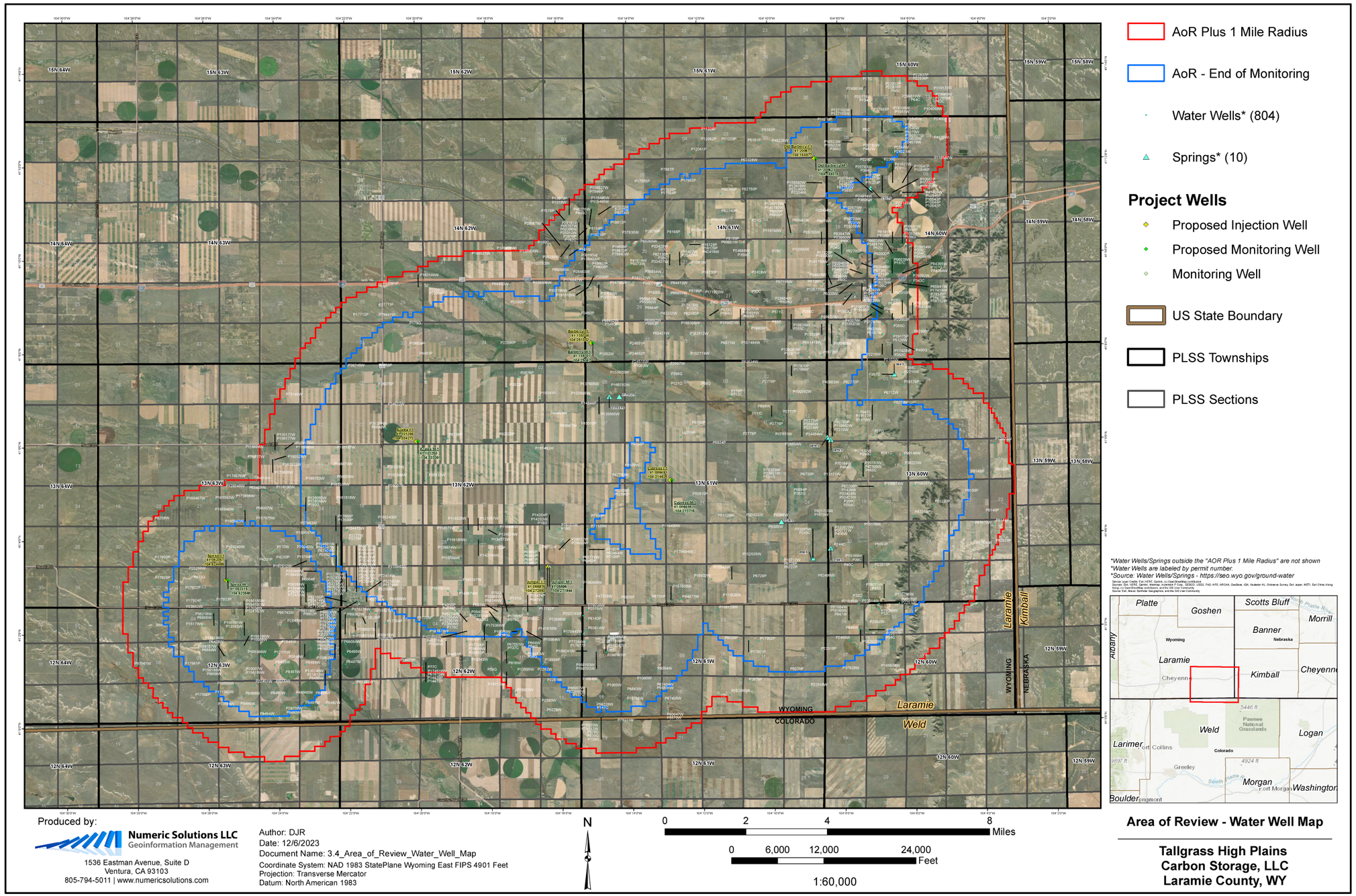



Figure B.2—Area of review and project basemap.

## B.2 Model Background

A representation of the reservoir was constructed from available well logs and interpreted formation tops (refer to *Appendix A*). Data was modeled using SLB's Petrel™ software to form a static geocellular model of discrete layers including the Chugwater and Goose Egg (top seals), the Lyons Formation (injection zone), and Satanka Formation (bottom seal). The dynamic geocellular model is comprised of approximately 14 million, 500 ft by 500 ft, hexahedral grid cells and encompasses an area of 5,800 square miles. Reservoir rock properties are geostatistically distributed in the Lyons Formation.

The geologic model is an input for GEM, a commercial compositional finite difference reservoir simulator, maintained and distributed by the Computer Modeling Group (CMG). GEM is one of the most technically sound reservoir-simulation software packages and is best suited to the compositional nature of carbon dioxide injection and storage. GEM utilizes equation-of-state (EOS) algorithms and advanced computational methods to evaluate key characteristics of fluid flow in the reservoir to produce accurate and dependable simulation models for carbon sequestration. Numerical simulations were run to forecast the subsurface behavior of supercritical $CO_2$, pressure buildup from $CO_2$ injection, and to output parameters, such as pressure and $CO_2$ saturation, used in the evaluation of the AoR.

## B.3 Data Sources

The data sources used to construct the static geocellular model include well logs, 2D seismic data, and elements drawn from available literature.

As discussed in *Section 2.3.3*, regional and reservoir-specific publications allowed High Plains to perform petrophysical analysis on offset wells to effectively evaluate the potential injection reservoirs and confining zones within the overall section. Log analysis was performed on a total of 47 wells within the region. The analyzed wells were then incorporated into the static geomodel and used to correlate formation tops and calculate formation properties, such as porosity, permeability, and salinity. Publicly available open-hole log data used in the static geomodel, included gamma-ray, spontaneous potential, resistivity, porosity (sonic, neutron, density), photoelectric factor, formation imager, caliper, sidewall core, whole core, or any related analyses.

Available 2D seismic data was calibrated using well ties and was used to further search for evidence of faulting, structural changes, and reservoir thickness not identified from well logs. *Section 2.3.4* further elaborates on how seismic data was incorporated into the static model.

Core samples taken at the Juniper M-1 well directly measured site specific relative permeability, porosity, and capillary pressure in the Goose Egg, Chugwater, and Lyons formations. These data have been incorporated into the geomodel.

## B.4 Overview of Simulation Activities

### *B.4.1 Model of the Injection Zone and Overlying/Underlying Seals*

The proposed injection interval is the Permian Lyons Formation. The Lyons Formation within the AoR is an aeolian sandstone. Red beds comprise most of the sandstone, which contains quartz overgrowths, calcite cement, and iron oxide coating. Lithofacies within the Lyons vary due to a complex depositional environment and subsequent diagenetic cementation. Sand development occurred on a regional high between evaporite basins that spanned parts of southwest Nebraska, southeast Wyoming, and northeast Colorado, as depicted in Figure B.3.

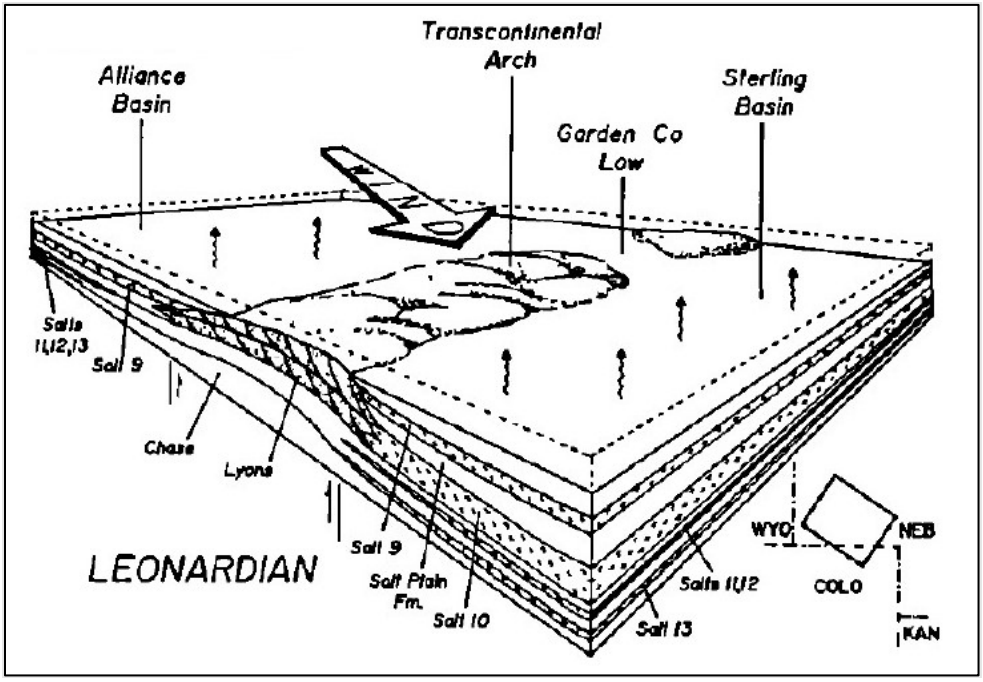



Figure B.3—Mapped facies changes within the Lyons Formation (Oldham 1996).

This resulted in the deposition of a regional sand body within the Lyons Formation that trends southwest to northeast over the EWS Hub. The Lyons Formation is anticipated to contain sandstone at the EWS Hub location with increasing evaporite content to the northwest and southeast, which will help impede lateral migration of injected $CO_2$ in those directions. The Lyons Formation dips gently to the west (Figure B.4), is regionally continuous, and is about 55 ft thick (Figure B.5) and encountered at -4,012 ft subsea true vertical depth near the proposed Spirea I-1 location.

The Lyons gross isopach ranges from 50 ft to 100 ft, demonstrating variable thickness of the formation within the mapped area. Observed thickness changes are likely due to key facies changes that occur when moving northwest from the EWS Hub location

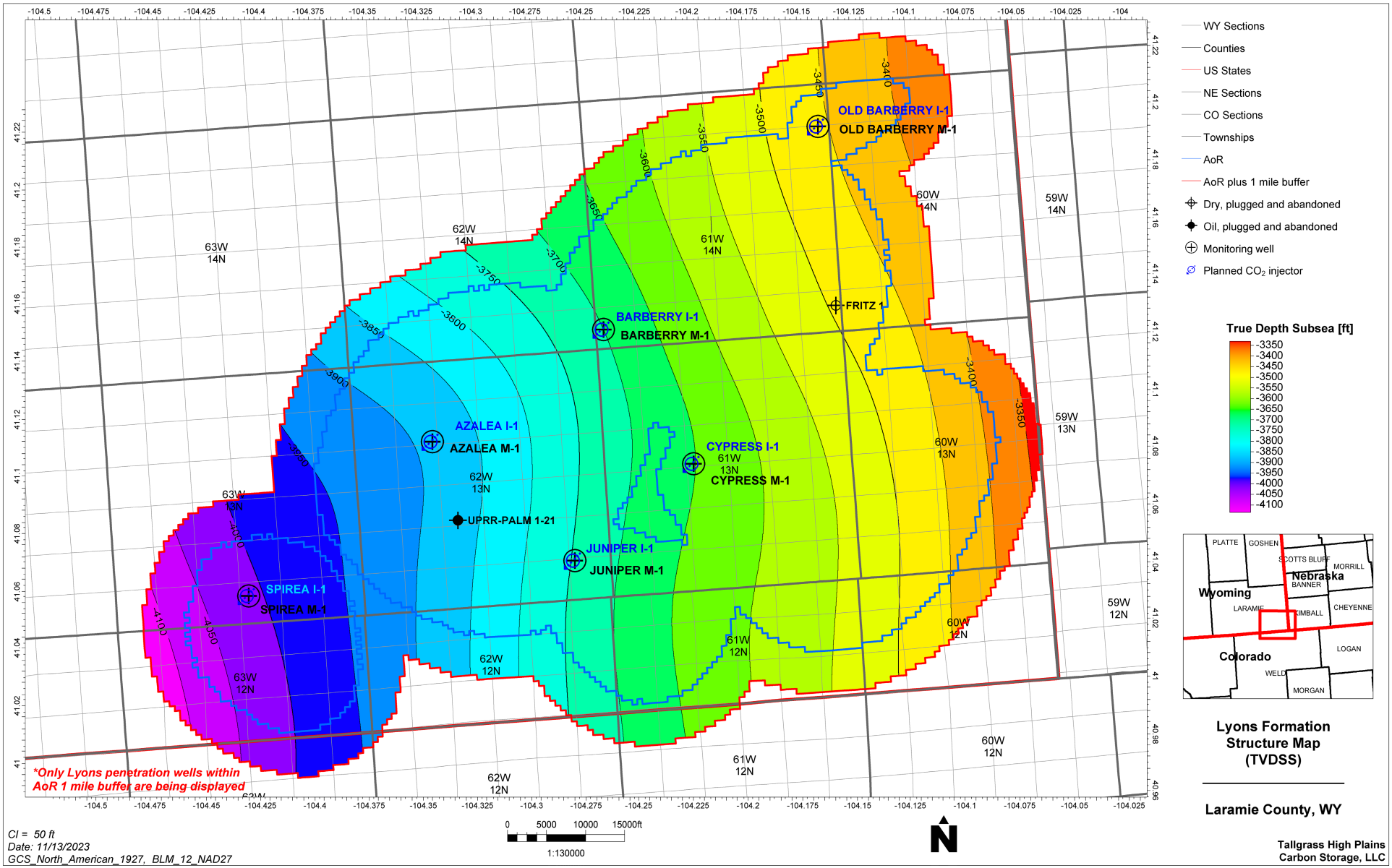



Figure B.4—Subsea structure map on the top of the injection zone, the Lyons Formation.

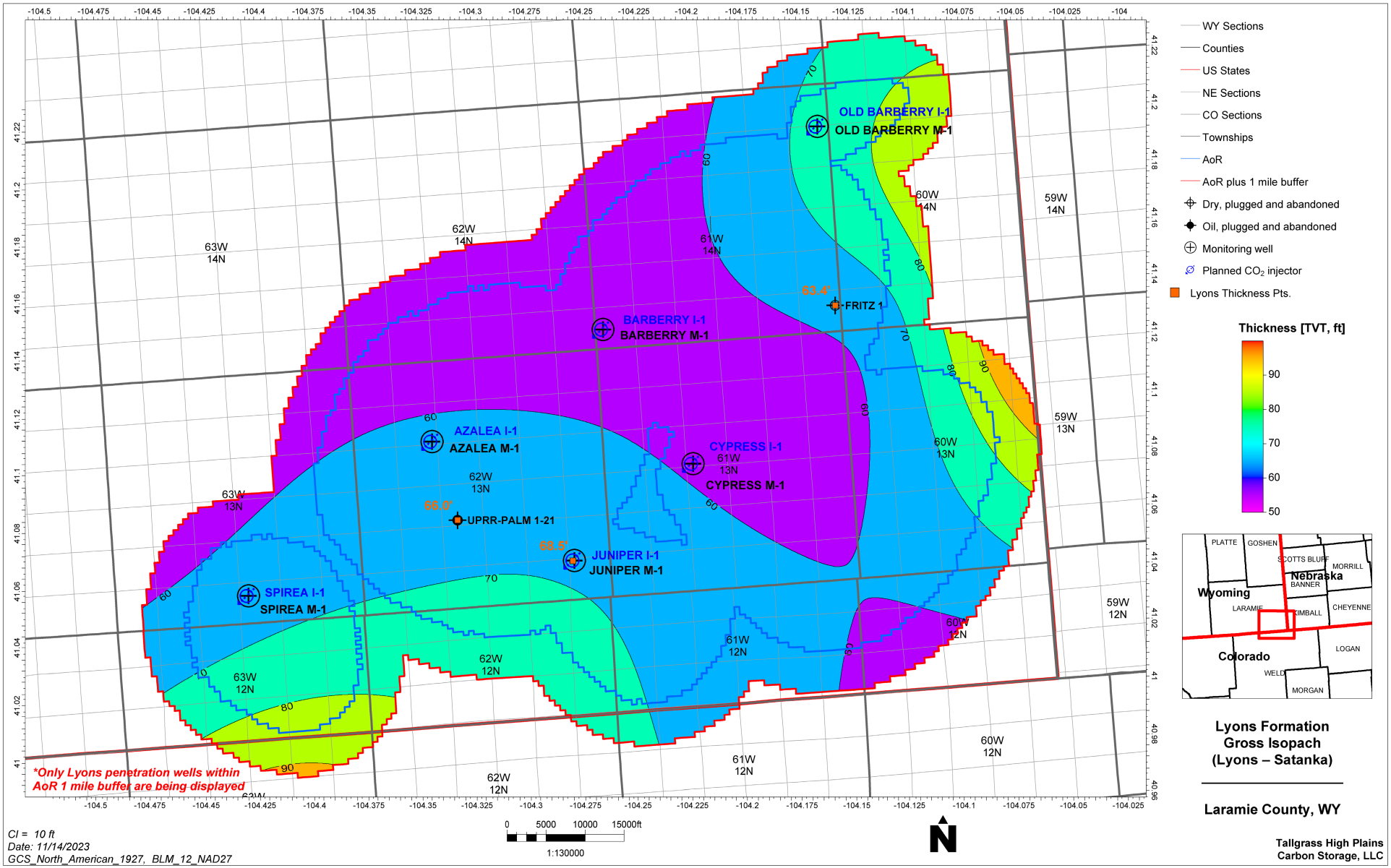



Figure B.5—Gross isopach map of the injection zone, the Lyons Formation.

Upper confinement of the Lyons injection interval is provided by a >500 ft thick, regionally extensive composite of the overlying Goose Egg and Chugwater formations. The Goose Egg immediately overlies the Lyons injection interval and is anticipated to be encountered at approximately -3,743 ft SSTVD in the Spirea I-1 well (Figure B.6), with a gross thickness of approximately 300 ft (Figure B.7). The Goose Egg is characterized by a mixture of sealing facies with very low porosity and permeability, restricting the migration of fluid. The Chugwater conformably overlies the Goose Egg Group and provides additional geologic confinement. It consists of brick-red shale and siltstone that is slightly sandy and evenly bedded. Regional mapping performed by High Plains indicates that Spirea I-1 will encounter the top of the Chugwater Formation at approximately -3,464 ft SSTVD (Figure B.6) with a gross thickness of approximately 230 ft (Figure B.8).

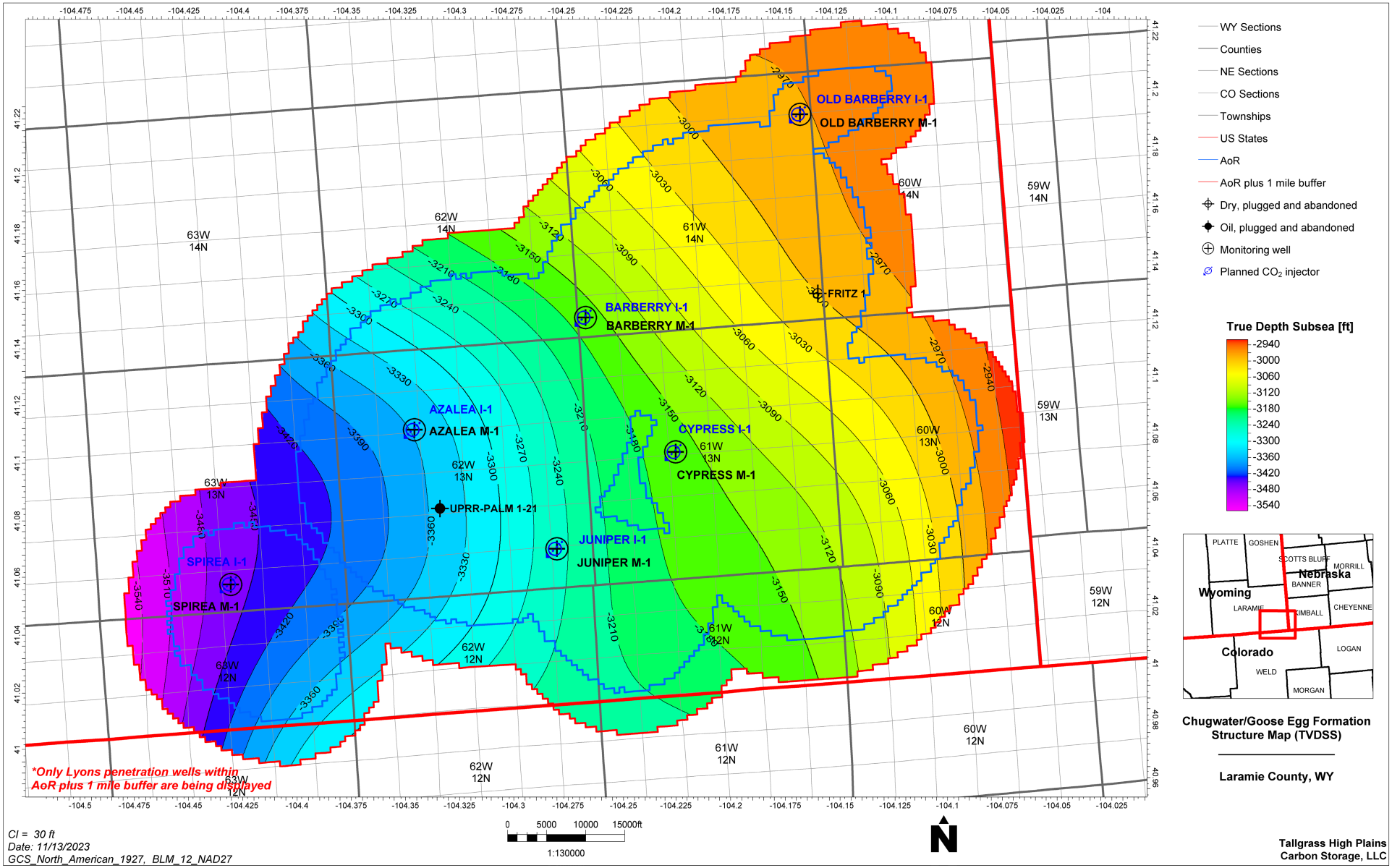



Figure B.6—Subsea structure map on the top of the Chugwater/Goose Egg formations.

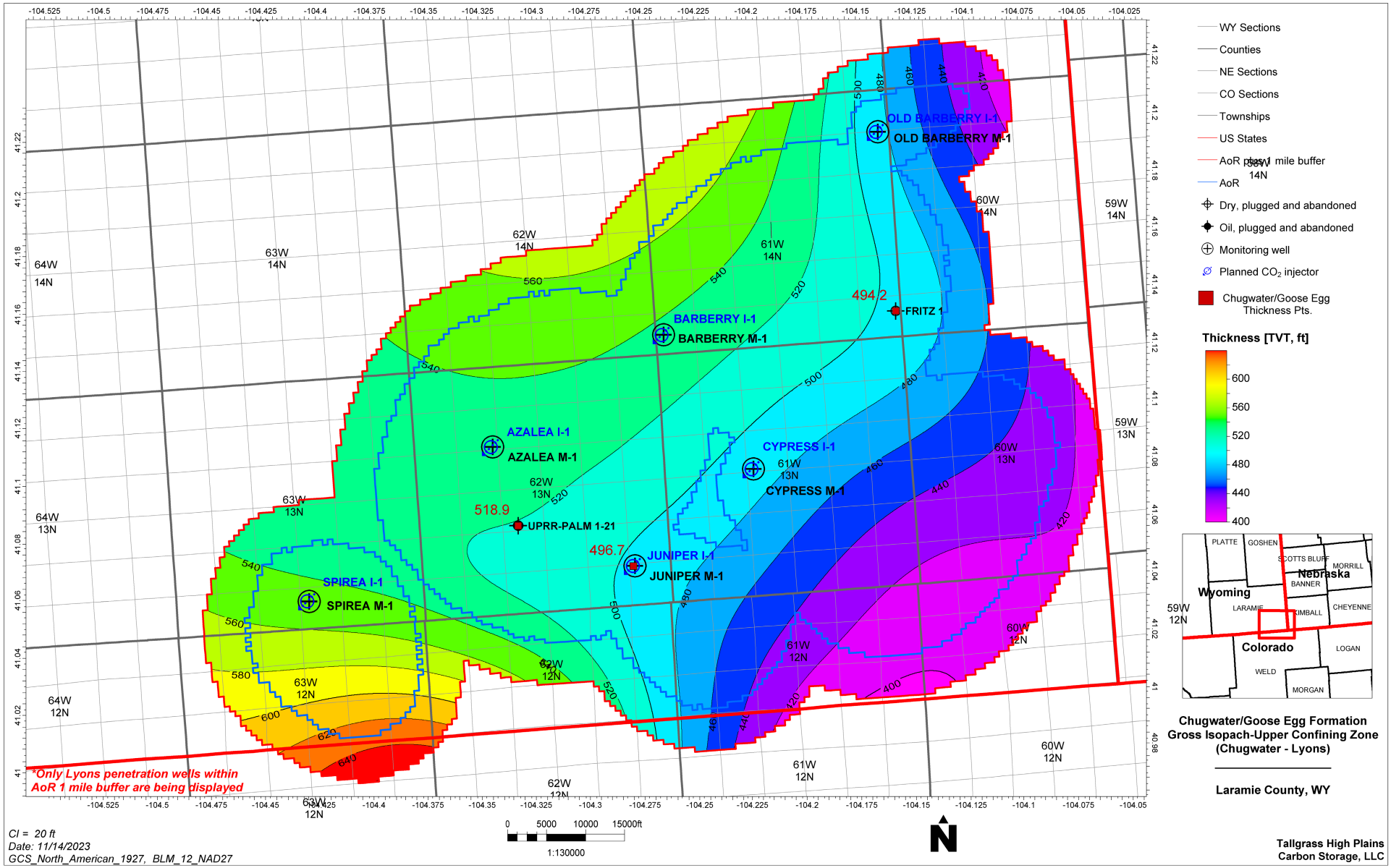



Figure B.7—Gross isopach map of the Goose Egg Formation.

Lower confinement of the Lyons Formation is provided by the underlying Satanka Formation. The Satanka unconformably overlies the Wolfcamp Formation and is anticipated to be encountered at approximately -4,077 ft SSTVD (Figure B.8) in the Spirea I-1 well with a gross thickness of approximately 200 ft (Figure B.9). The lithology of the Satanka Formation is anticipated to consist of shale and siltstone with the potential for minor evaporite interbeds.

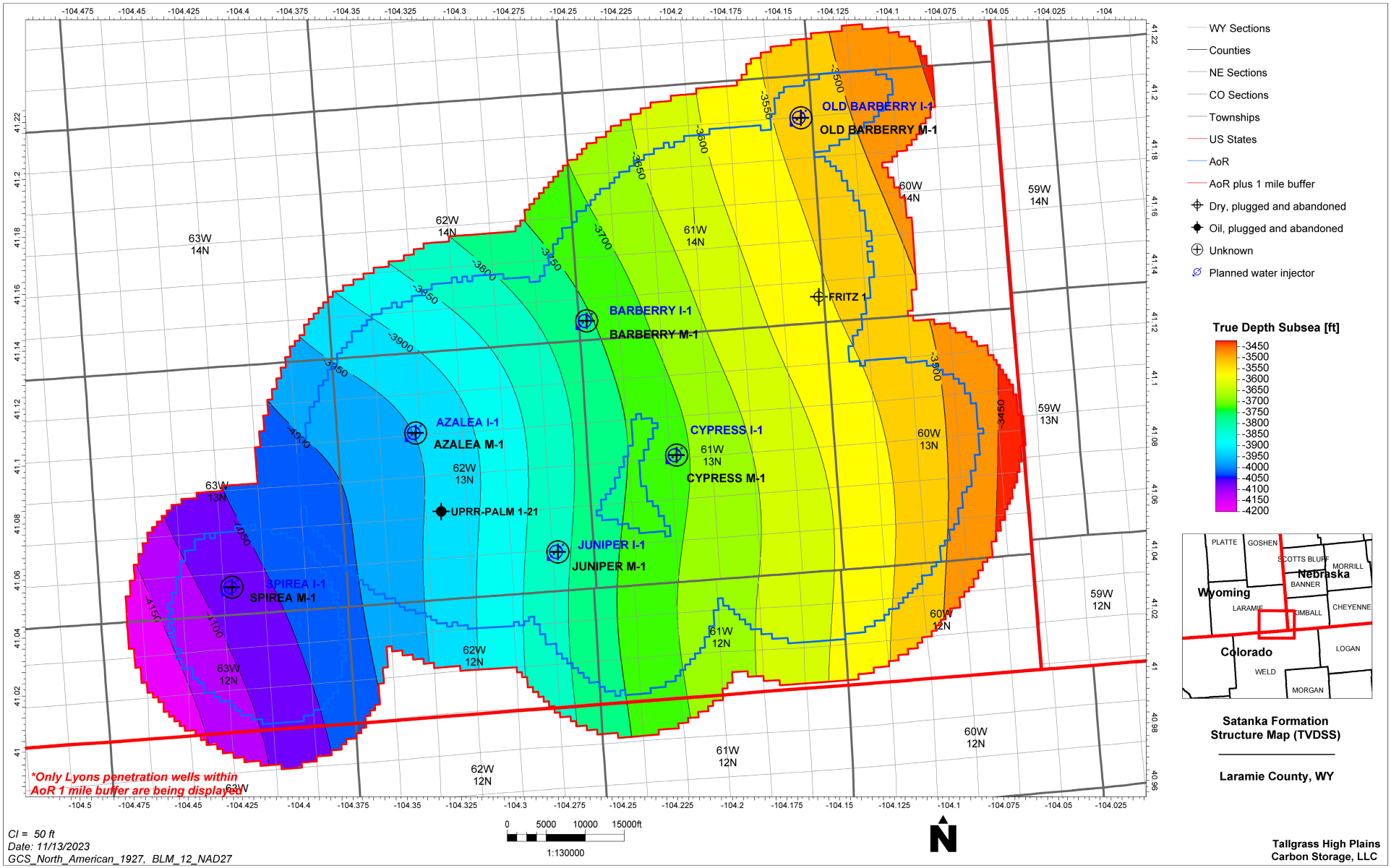



Figure B.8—Subsea structure map of the Satanka Formation.

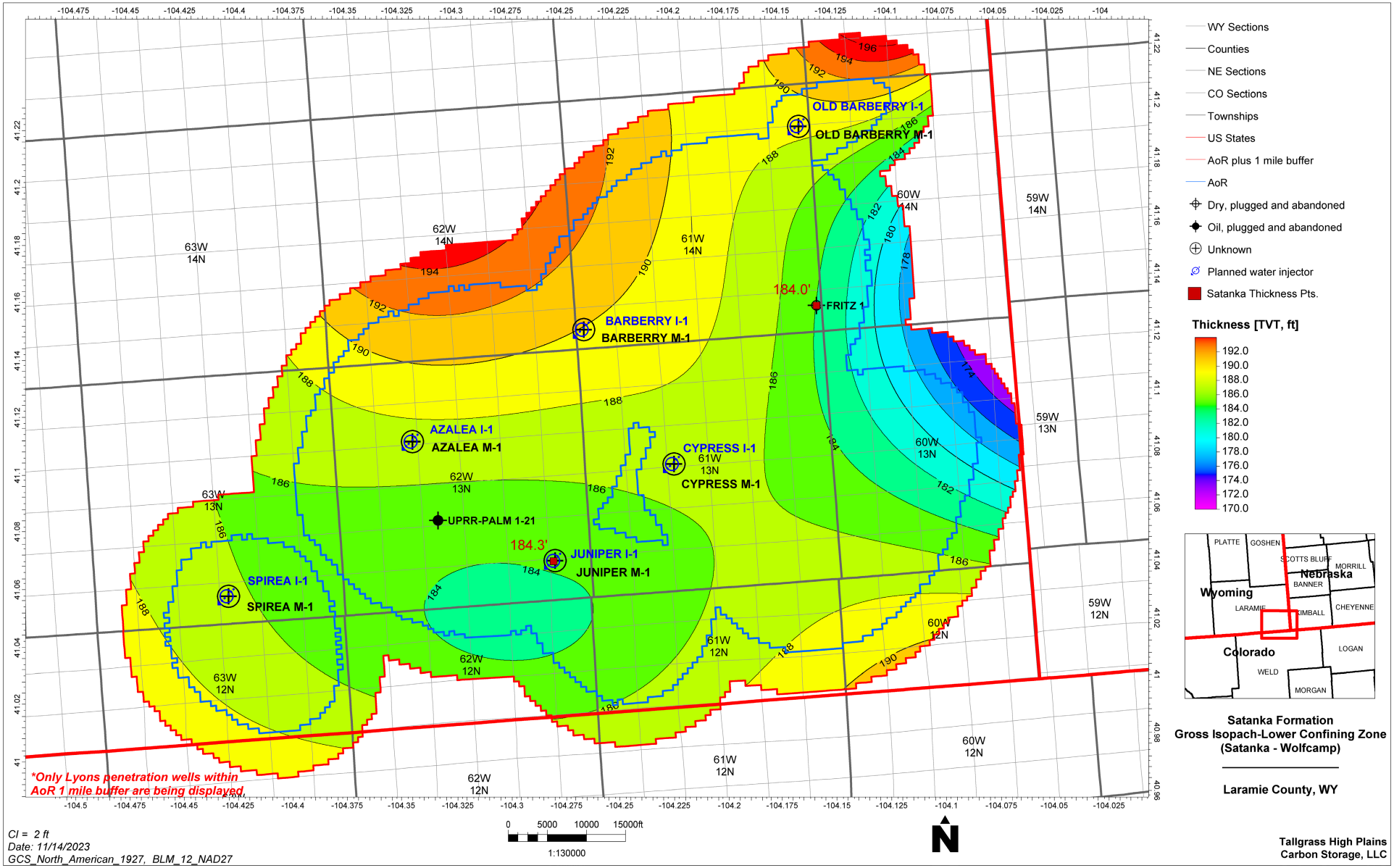



Figure B.9—Gross isopach map of the Satanka Formation.

### *B.4.2 Model Structural Framework*

A geocellular model having 500 ft by 500 ft hexahedral grid cells was generated in SLB's Petrel™ software. The geocellular model covers an area 102 miles by 57 miles that spans the entire EWS domain including the Spirea I-1 Project area. Surfaces for the four primary zones of interest, Chugwater, Goose Egg, Lyons, and Satanka (Figure B.4 through Figure B.9) were interpreted from well logs and seismic data. An average cell thickness of 4.52 ft was used to characterize Lyons Formation. Petrophysical analyses conducted on 47 wells within the model boundary was used to determine, porosity (e.g., Figure B.11 and Figure B.12), permeability (e.g., Figure B.15 and Figure B.16), and salinity for each stratigraphic zone. Using the values derived from log analysis, properties in the geocellular static model were assigned by taking the continuous range of the property and upscaling the value to match the final grid cell resolution using the arithmetic average over each cell. Property distribution in the Lyons Formation consisted of applying a kriging algorithm from upscaled logs, guided by an experimental spherical variogram, with major and minor range of 100,000 ft and a vertical range of 50 ft for each zone as seen in Figure B.10.

Permeability was distributed in the geocellular static model using the porosity, permeability relationship shown in Figure B.13. The correlation of porosity to permeability is defined by the best-fit trend line of the measured data taken from the Razor 26J-2633L (API: 051233749500), Marathon-Avalo 1-32 (API: 05123106700) and the Juniper M-1 (API: 490212954800). These values were then converted into brine permeability based on the Swanson $K_{air}/K_{brine}$ relationship (Swanson 1981). If the brine permeability was calculated to be greater than the air permeability, the air permeability was used. Figure B.14 shows the relationship between $K_{air}$ and $K_{brine}$. Figure B.17 shows the distribution of permeability as equal in the I and J planes further demonstrating the lateral homogeneity of permeability in the system. Observed values of porosity calculated from offset well logs can be in excess of 30% yielding permeabilities of 1,029 mD. To constrain these anomalously high values of permeability a cutoff of 1,029 mD was applied to the model.

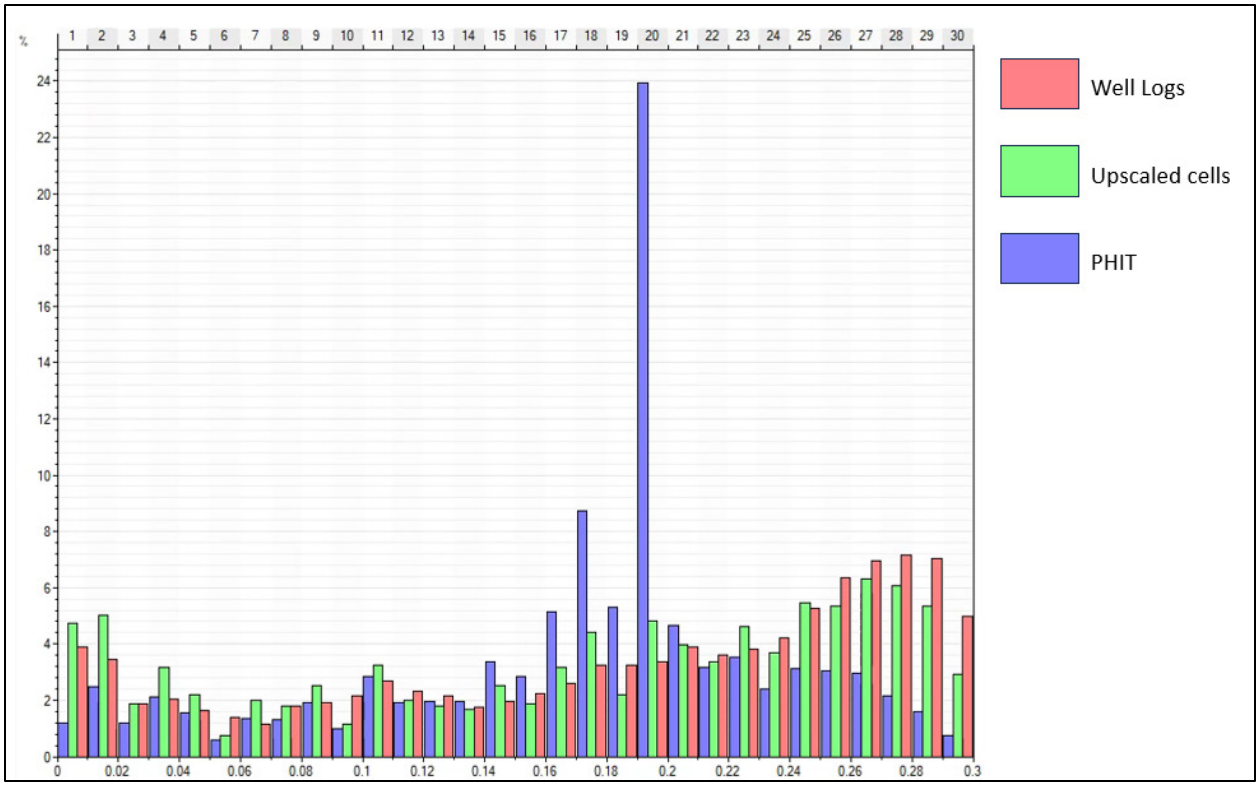



Figure B.10—Histogram of porosity values in the Lyons Formation from well logs. Red represents well logs; green represents upscaled cells; purple represents the final property model following depth adjustment.

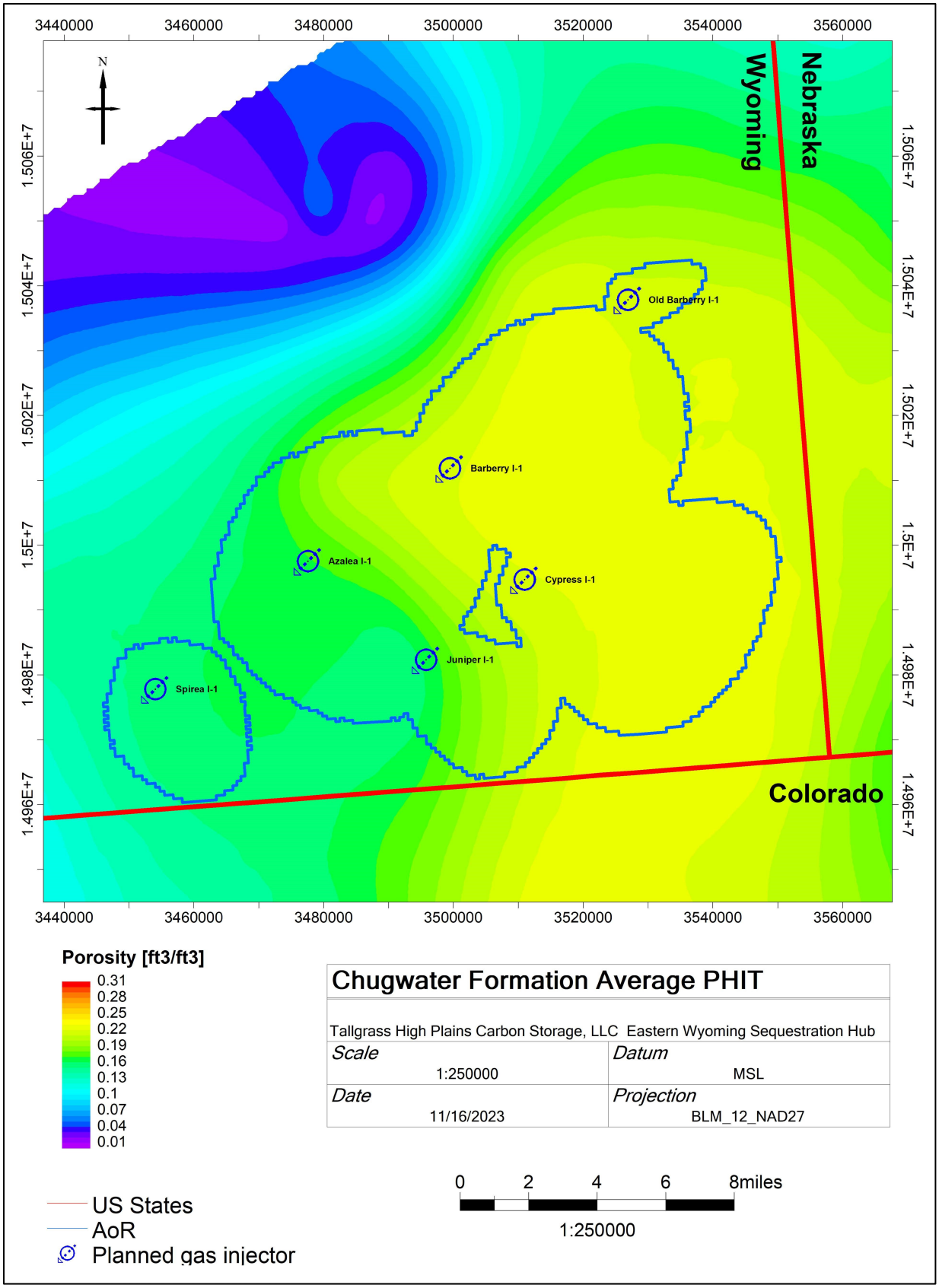



Figure B.11—Average total porosity within the entire (gross) Lyons Sandstone.

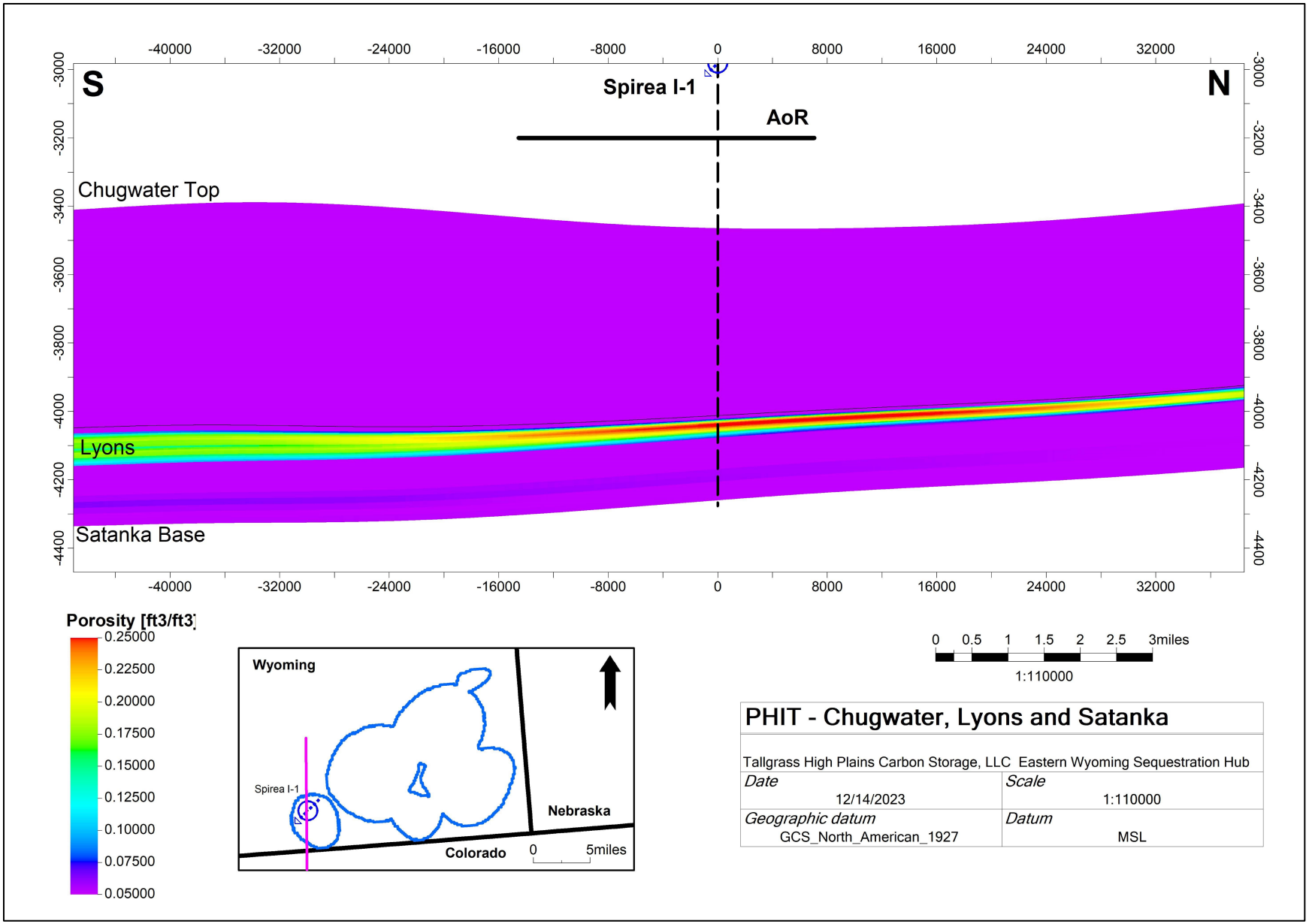



Figure B.12—South to north cross-section at the location of the proposed Spirea I-1 injection well showing distributed total porosity values in the Chugwater, Lyons, and Satanka Formations across the area of rreview.

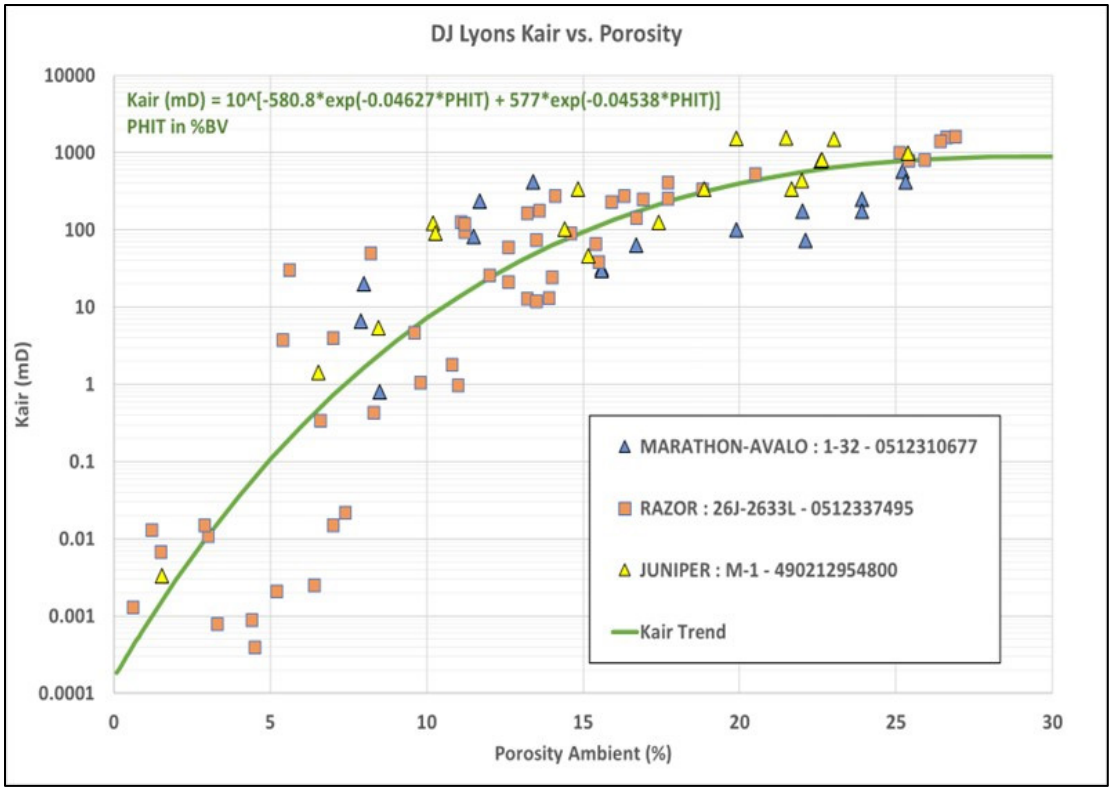



Figure B.13—Porosity and permeability relationship.

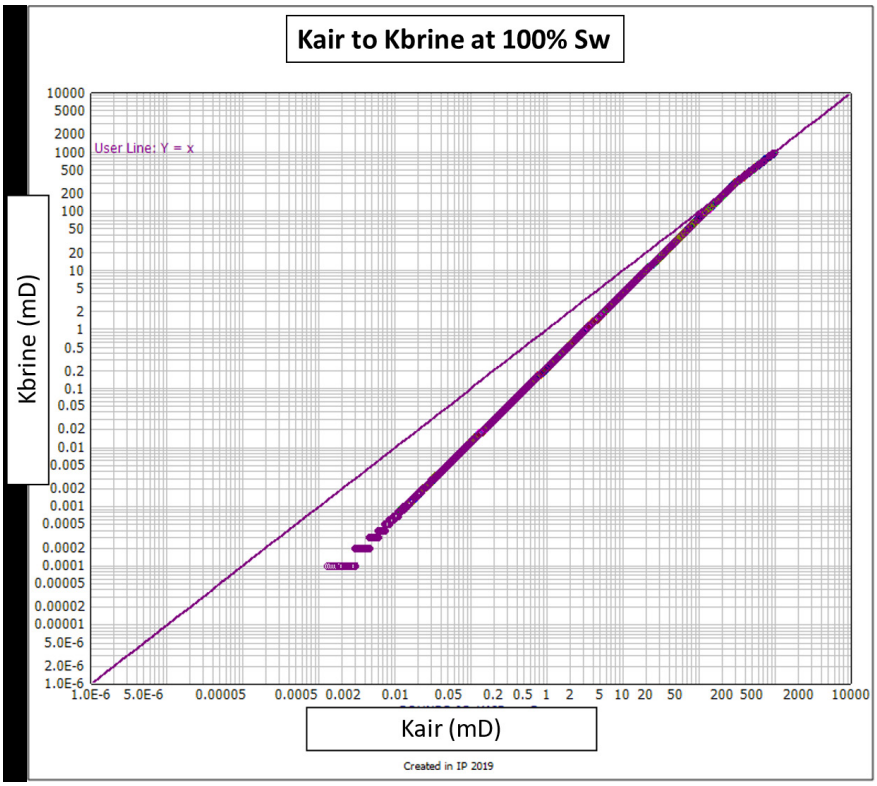



Figure B.14—$K_{air}$ vs $K_{brine}$ (Swanson 1981).

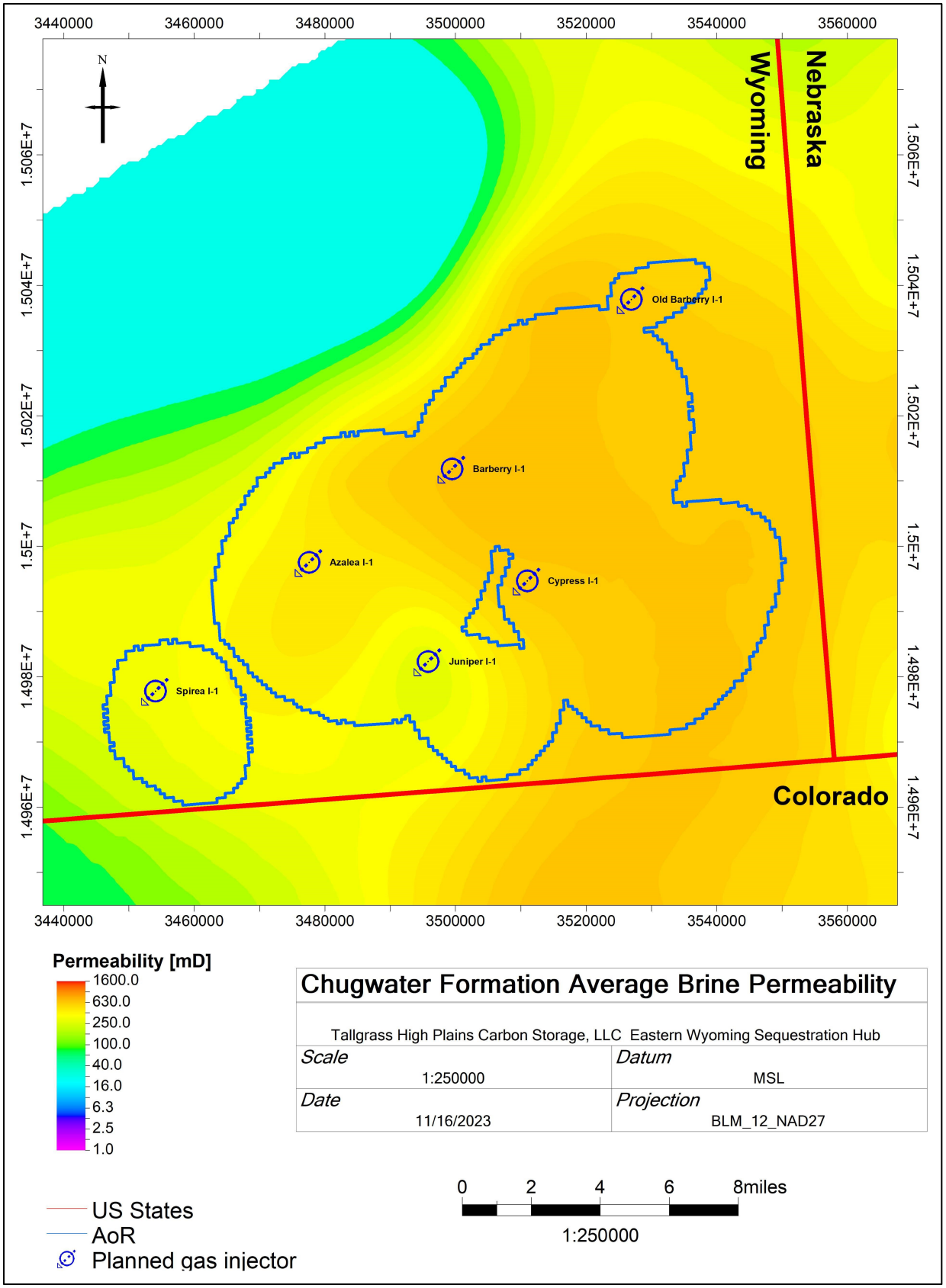



Figure B.15—Average brine permeability in the Lyons Sandstone across the dynamic model domain.

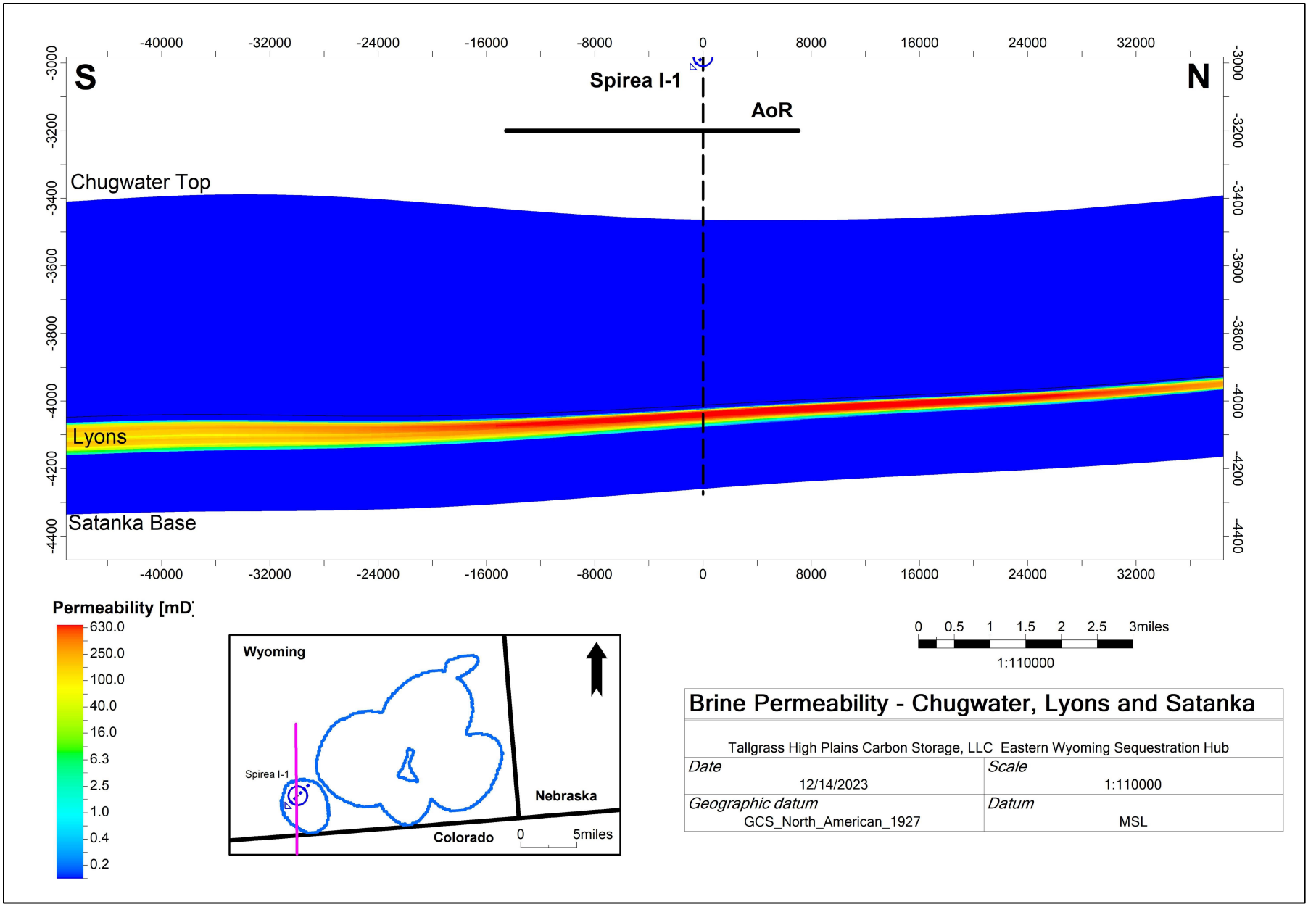



Figure B.16—South to north cross section at the location of the Spirea I-1 proposed injection well showing modeled brine permeability.

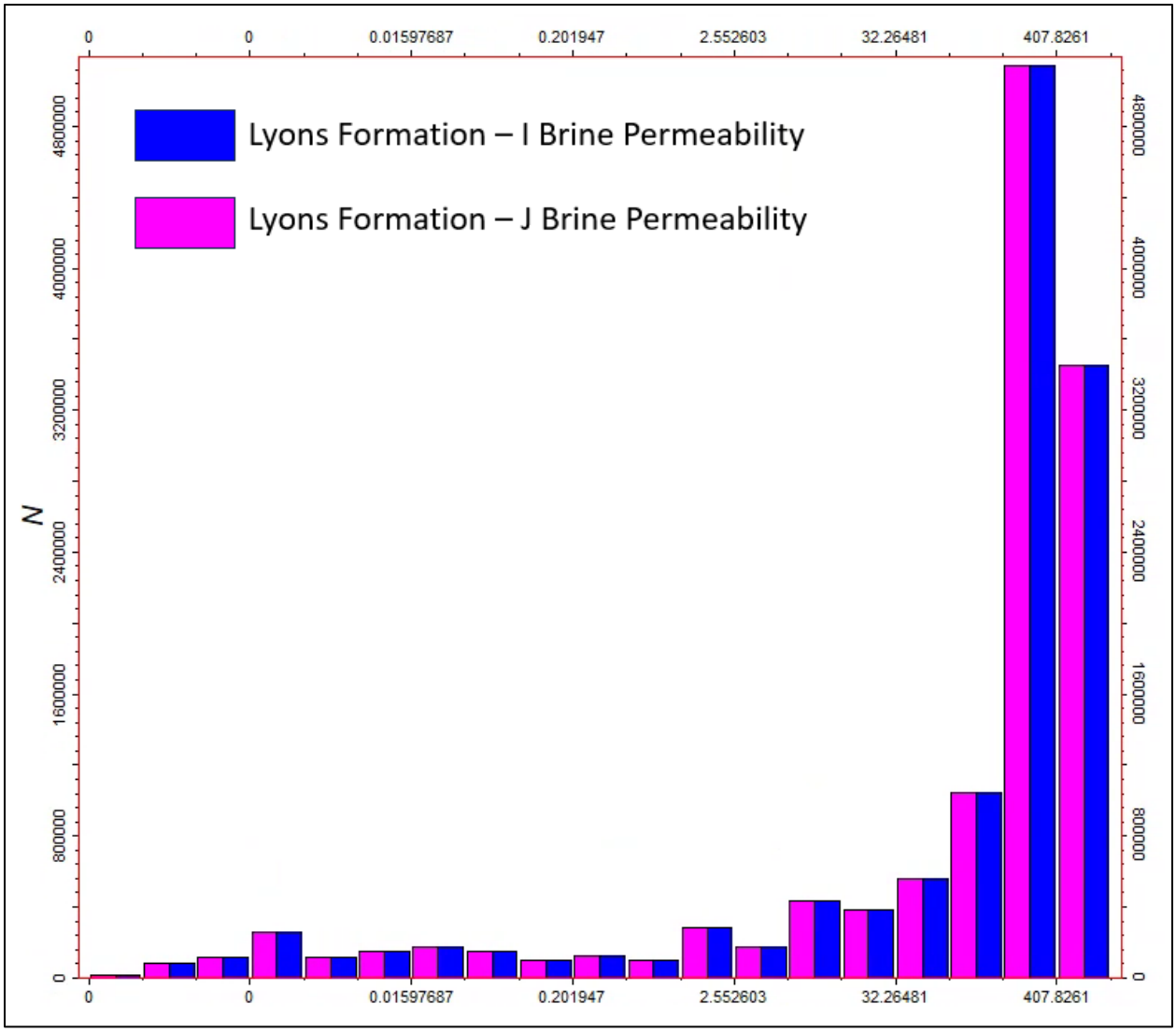


Figure B.17—Permeability distribution in the I and J (horizontal) direction

## B.5 Numerical Simulation

### *B.5.1 Initial Conditions Summary*

The dynamic simulation model was constructed as a pseudo-infinite acting reservoir that is fully saturated with brine. Based on 2D seismic interpretation, and log information collected at the Juniper M-1, the sands within the Lyons Formation have an average gross thickness of 55 ft. The Spirea I-1 well was completed in the model with all layers in the Lyons Formation open to flow. From drill stem test data in adjacent wells, it was determined that the reservoir has a pressure gradient of 0.34 psi/ft. A reservoir temperature gradient of 2.07 degrees Fahrenheit (°F)/100 ft with a mean surface temperature of 60°F was used. Average salinity of the brine fluid in the reservoir was measured at the Juniper M-1 with a value of 230,000 mg/L. Model inputs are summarized in Table B.1.

Table B.1—Initial assumptions summary.

| Assumption | Units | Source | Value |
|---|---|---|---|
| Average Reservoir Permeability | mD | Logs | 322 |
| Average Reservoir Porosity | % | Logs | 17 |
| Average Gross Thickness | ft | Juniper M-1 | 55 |
| Pore Gradient | psi/ft | Juniper M-1 | 0.34 |
| Fracture Gradient | psi/ft | Juniper M-1 | 0.57 |
| Temperature Gradient | °F/100 ft | Juniper M-1 | 2.07 |
| Surface Temperature | °F | Assumed | 60 |
| $CO_2$ Phase | | Calculated | Supercritical |
| Salinity | mg/L | Juniper M-1 | 230,000 |

#### *B.5.1.1 Pore Pressure Gradient Discussion*

A review of drill stem tests (DSTs) obtained throughout the Denver-Julesberg (DJ) Basin was conducted to determine the initial reservoir pressure and summarized in Figure B.18. The final shut-in period of the test shows a trend of 0.34 psi/ft. A literature review of the area confirmed that the Project Area is generally under-pressured relative to the hydrostatic case of a freshwater column equal to a gradient of 0.433 psi/ft (Belitz and Bredehoeft 1988, Birchall et al. 2022).

Offset saltwater disposal (SWD) well modeling was also conducted to monitor the historical effect SWDs had on the reservoir pressure prior to supercritical $CO_2$ injection. This is discussed further in *Appendix C* (*Section C.2.3*, in *Well Assumptions*).

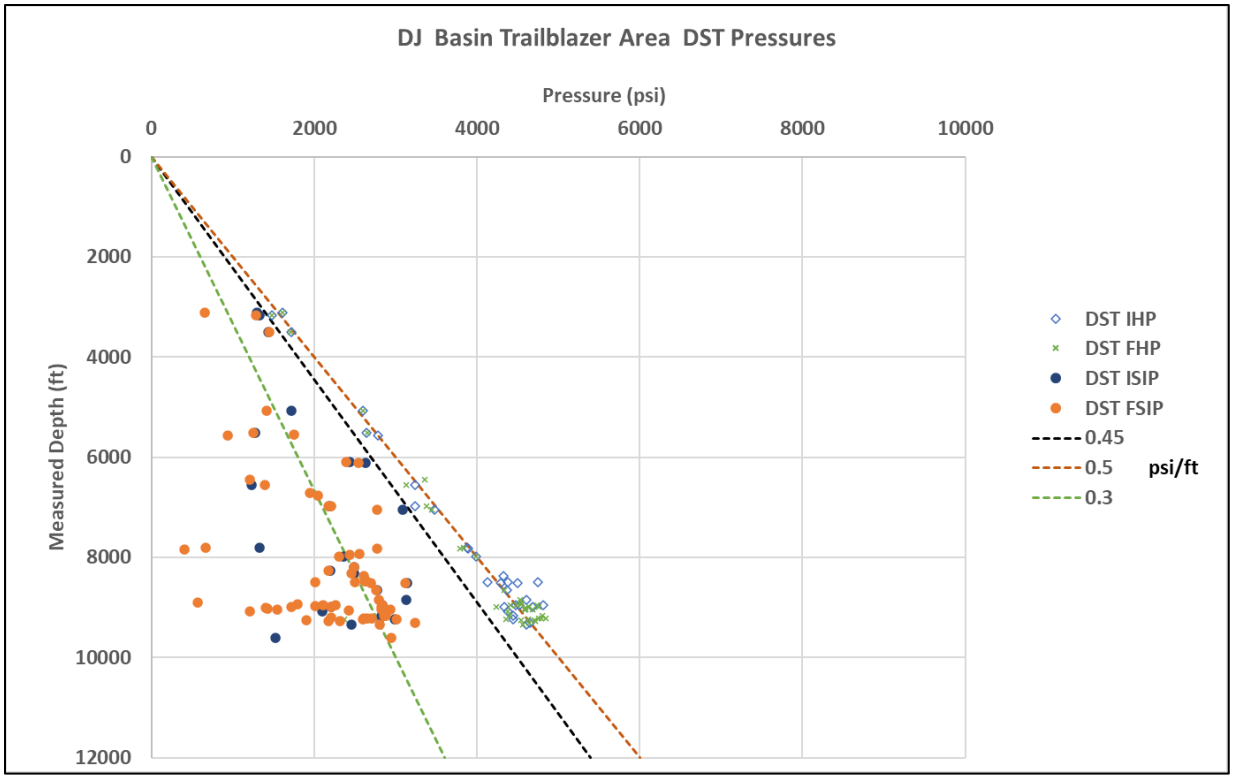


Figure B.18—DST pressure vs. depth.

### *B.5.1.2 Fracture Gradient Discussion*

An industry standard methodology was used to determine fracture gradient of a given rock. For this method, an isotropic model was used based on the dipole sonic log recorded in Juniper M-1. Further data will be recorded in Juniper I-1 to confirm interpretation from Juniper M-1. Once additional data has been gathered, updated inputs will be incorporated into an anisotropic model that will be used to account for the heterogeneity of the rock. At this time, our best estimate of fracture gradient is 0.57 psi/ft. In accordance with the Wyoming Department of Environmental Quality's (WYDEQ) Water Quality Rules, Chapter 13 (020-0011-13 Wyoming Code R. **§24.18(a)**), whereby injection operations must not exceed 90% of the fracture gradient, a maximum injection pressure gradient used in the dynamic simulation model was 0.51 psi/ft.

Equation B.1—Equation used to calculate maximum injection pressure gradient.

$$P_{Constraint} = 0.9 \times FG \left(\frac{psi}{ft}\right)$$

$$P_{Constraint} = 0.9 \times 0.57 \left(\frac{psi}{ft}\right)$$

$$P_{Constraint} = 0.51 \left(\frac{psi}{ft}\right)$$

### *B.5.1.3 Supercritical Phase*

$CO_2$ will be injected in a supercritical phase at the surface. The model input parameters shown in Table B.1 are shown on Figure B.19 and demonstrate that at reservoir conditions sufficient temperature and pressure exist to support a supercritical phase.

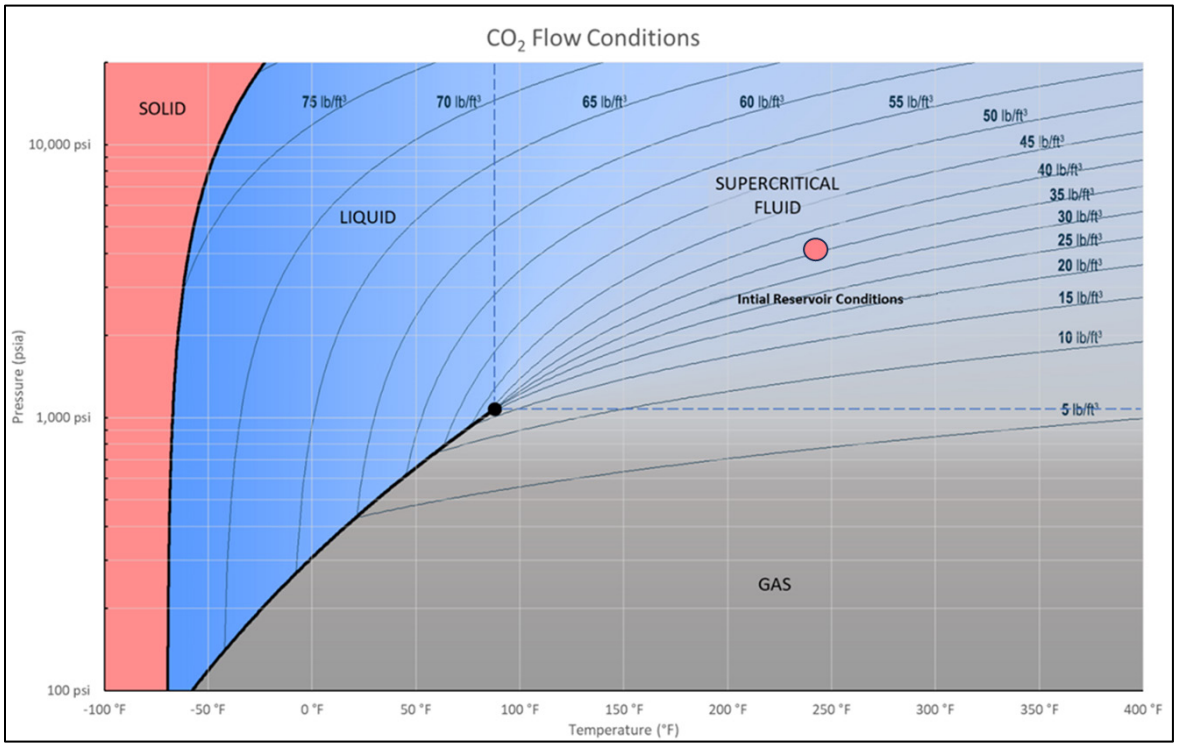



Figure B.19—$CO_2$ phase diagram.

### *B.5.1.4 Reservoir Salinity*

A study of the Lyons Formation salinities adjacent to the Project area were conducted to provide a reginal trend of values. All regional data was acquired from a national produced-water database generated by the U.S. Geological Survey (USGS) and used to calibrate the calculated salinities in the model. A map of total dissolved solids (TDS) is shown in Figure B.20.

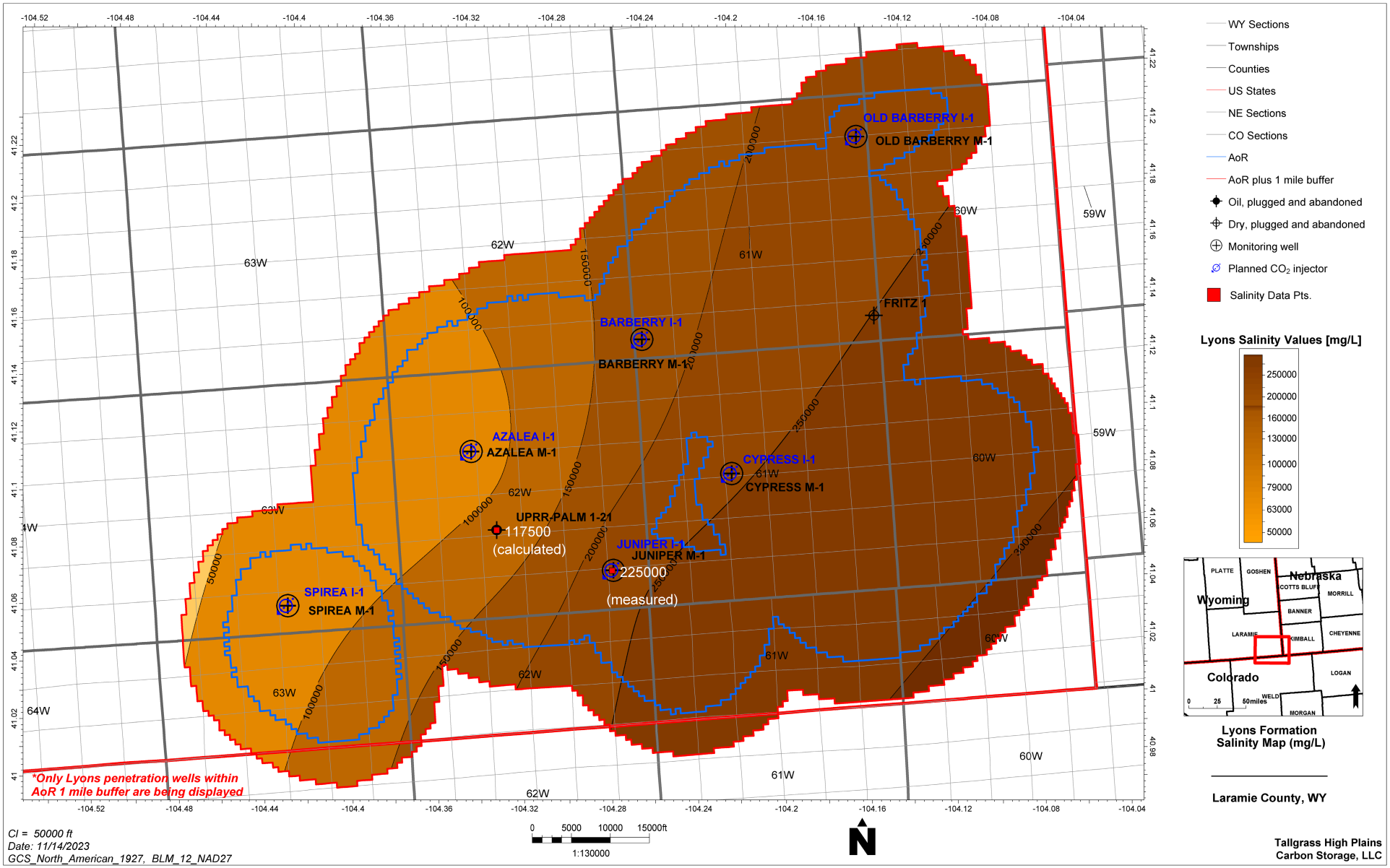



Figure B.20—TDS concentration map (mg/L) of the Lyons Sandstone formation fluid.

Calculated salinities were derived from the (Waxman and Smits 1968) approach was used to evaluate the relationships between resistivity, porosity, clay conductivity, and water salinity. In 100% water-saturated intervals the formation resistivity ($R_o$) is related to the formation total porosity ($\phi_T$), water resistivity ($R_w$), clay conductivity ($BQ_v$), and the clay-free Archie factor (m*) through Equation B.2.

Equation B.2—Waxman and Smits (1968) equation.

$$\frac{1}{R_o} = \phi_T^{m^*}\left(\frac{1}{R_w} + BQ_v\right)$$

The $BQ_v$ term in Equation B.2 is further described by the ionic conductance of the clay exchange cations (B) and the cation exchange capacity (CEC) of the bulk rock per unit pore volume ($Q_v$). The B term is evaluated as a function of the equivalent brine NaCl concentration and temperature through an empirical correlation developed by (Dacy and Martin 2006). The $Q_v$ term is evaluated by considering the rock grain density ($r_g$), $\phi_T$, clay volume ($V_{cl}$), and the CEC of the pure clay ($CEC_{clay}$) through Equation B.3.

Equation B.3—Waxman and Smits (1968) equation $Q_v$ term.

$$Q_v = \frac{V_{cl}CEC_{clay}(1-\phi_T)}{100\phi_T}$$

Equation B.2 can be rearranged to evaluate the $R_w$ of 100% water-saturated intervals ($R_{wapp}$):

Equation B.4—Waxman and Smith (1968) equation re-arranged.

$$R_{wapp} = \left(\frac{1}{R_t\phi_T^{m^*}} - BQ_v\right)^{-1}$$

The $R_{wapp}$ from Equation B.4 is evaluated at downhole temperature and then corrected to 77°F or 25°C as the standard surface reference. A default m* value of 2 and 20 milliequivalents per 100 grams (meq/100 grams rock for $CEC_{clay}$) was used.

A local correlation from the USGS National Produced Waters Geochemical Database was used to relate the $R_{wapp}$ to TDS salinity. The produced water correlation presented as TDS vs. specific conductivity, is shown in Figure B.21. Water resistivity, when expressed in ohm-m at 25 C°, is converted to specific conductivity ($C_{wspec}$) by Equation B.5.

Equation B.5—Specific conductivity equation

$$C_{wspec} = \frac{10{,}000}{R_{wapp}}$$

Following the reginal study of salinity values in the Lyons Formation and the adjacent strata, a site-specific sample with a value of 230,000 mg/L was collected at the Juniper M-1. A value of 230,000 mg/L was used in the dynamic simulation model.

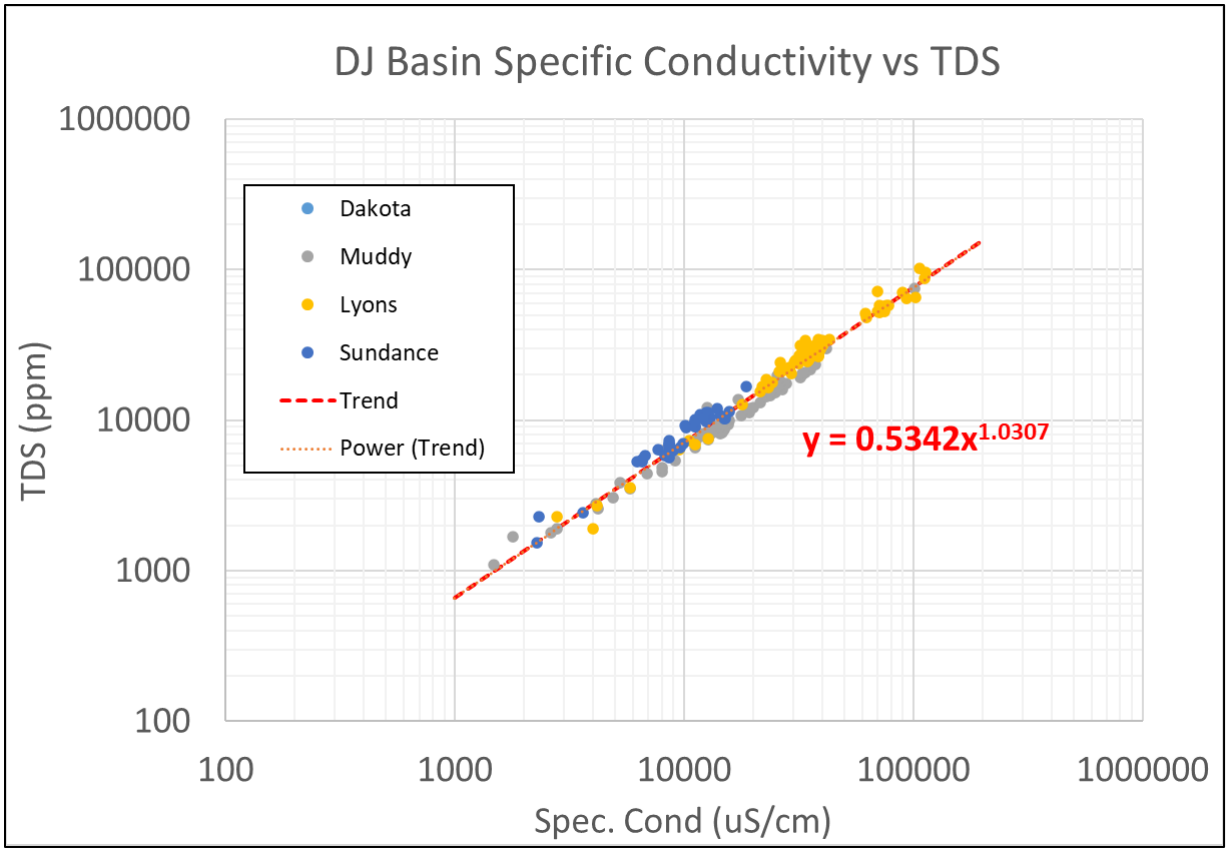



Figure B.21—Produced water correlation of TDS to the lab-measured specific conductance for different formations in the DJ Basin.

### *B.5.2 $CO_2$ Trapping Mechanisms*

Site specific trapping mechanisms identified as having sufficient data to support being modeled and describe the distribution of trapped and supercritical $CO_2$ include structural, stratigraphic, residual, and solubility trapping. Structural and stratigraphic trapping mechanisms are incorporated into the dynamic simulation through the static model. The geocellular static model represents facies distribution and couples the distribution of porosity and permeability as shown in the porosity, permeability transform (Figure B.13) to the dynamic simulation. In addition to the distribution of porosity and permeability, the dip of the injection zone impacts where buoyant and mobile volumes $CO_2$ will become trapped against low permeability baffles, or caprock as shown in Figure B.23. As shown in Figure B.22, the structural and stratigraphic trapping mechanisms used in the model have the greatest trapping contribution and are sufficient to hold the $CO_2$ in place indefinitely. Residual trapping as described by (Dongxiao Zhang, 2014) accounts for those volumes of $CO_2$ which are immobilized by relative permeability hysteresis and shown in the drainage and imbibition curves, Figure B.25 and the ratio of vertical permeability to horizontal permeability (kv/kh) applied in the dynamic model with a ratio of 0.1. Solubility trapping is incorporated into the dynamic simulation through Henry's law (Equation B.6) and further refined by versions of the Henry's constant correlations (Harvey 1996) to give improved results for $CO_2$ trapping. As shown in Figure B.22, the contribution of solubility trapping increases through the modeled timeframe and has sufficient capacity to hold $CO_2$ in place indefinitely.

Mineral trapping as shown in Figure B.22 has the lowest overall trapping contribution and least site-specific data from which to develop a model. For this reason, mineral trapping was not incorporated into the dynamic simulation.

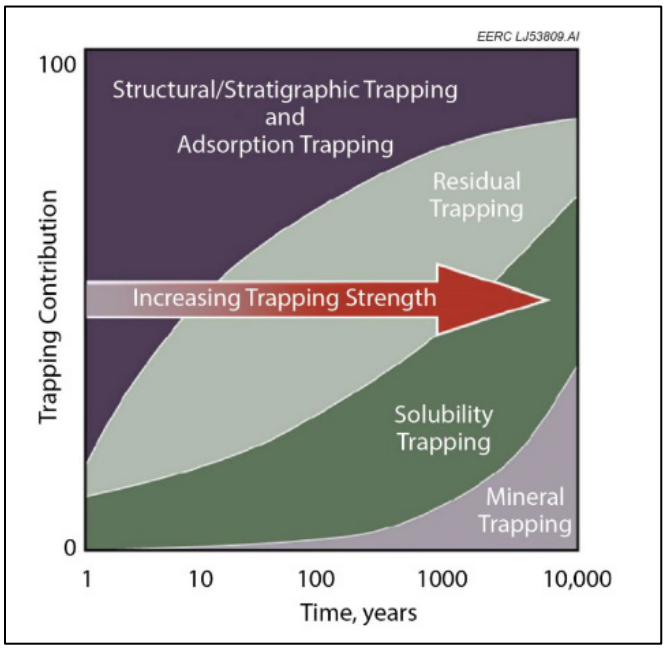



Figure B.22—Trapping mechanisms by strength and contribution (Lu Jin Et al. 2018 modified Intergovernmental Panel on Climate Change, 2005).

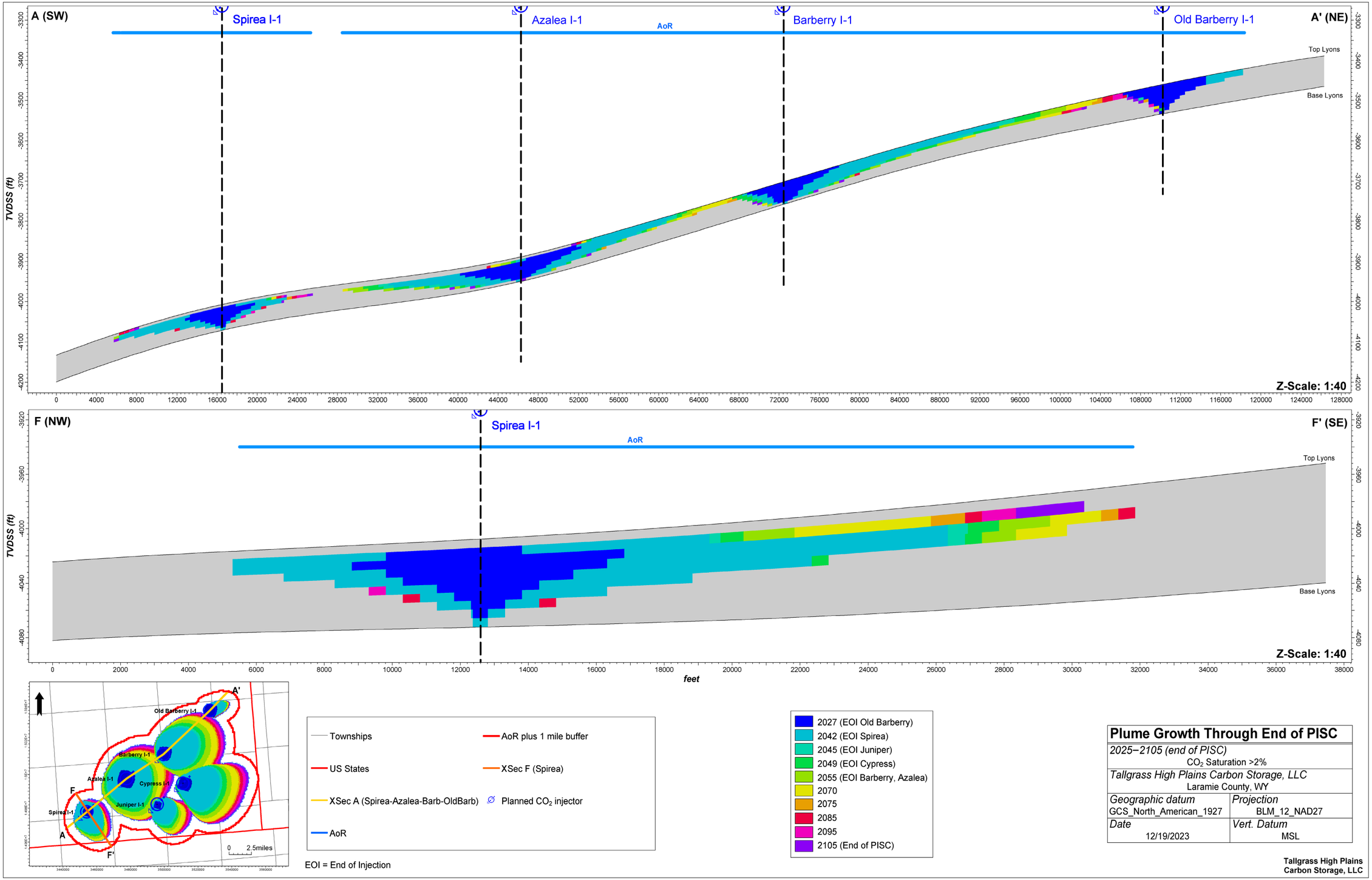



Figure B.23—Map and cross sections through the simulation model at the location of the Spirea I-1 showing a time lapse of $CO_2$ plume distribution (>2% saturation) starting in 2027 (2 years after the start of injection) through site closure (2055).

Equation B.6—Henry's Law

$$f = x * H$$

$$f = the\ fugacity\ of\ the\ compoent\ (bar)$$

$$x = composition\ of\ the\ component\ in\ the\ aqueous\ phase$$

$$H = Henry's\ Law\ constant\ mol\ L^{-1}\ bar^{-1}$$

At the end of the modeled timeframe (model year 2105), approximately 8.18 MMT of $CO_2$ is structurally trapped. Residual trapping stores 1.80 MMT. Solubility trapping accounts for approximately 0.61 MMT of $CO_2$ at the end of the model runtime. The modeled $CO_2$ fraction by phase is shown in Figure B.24.

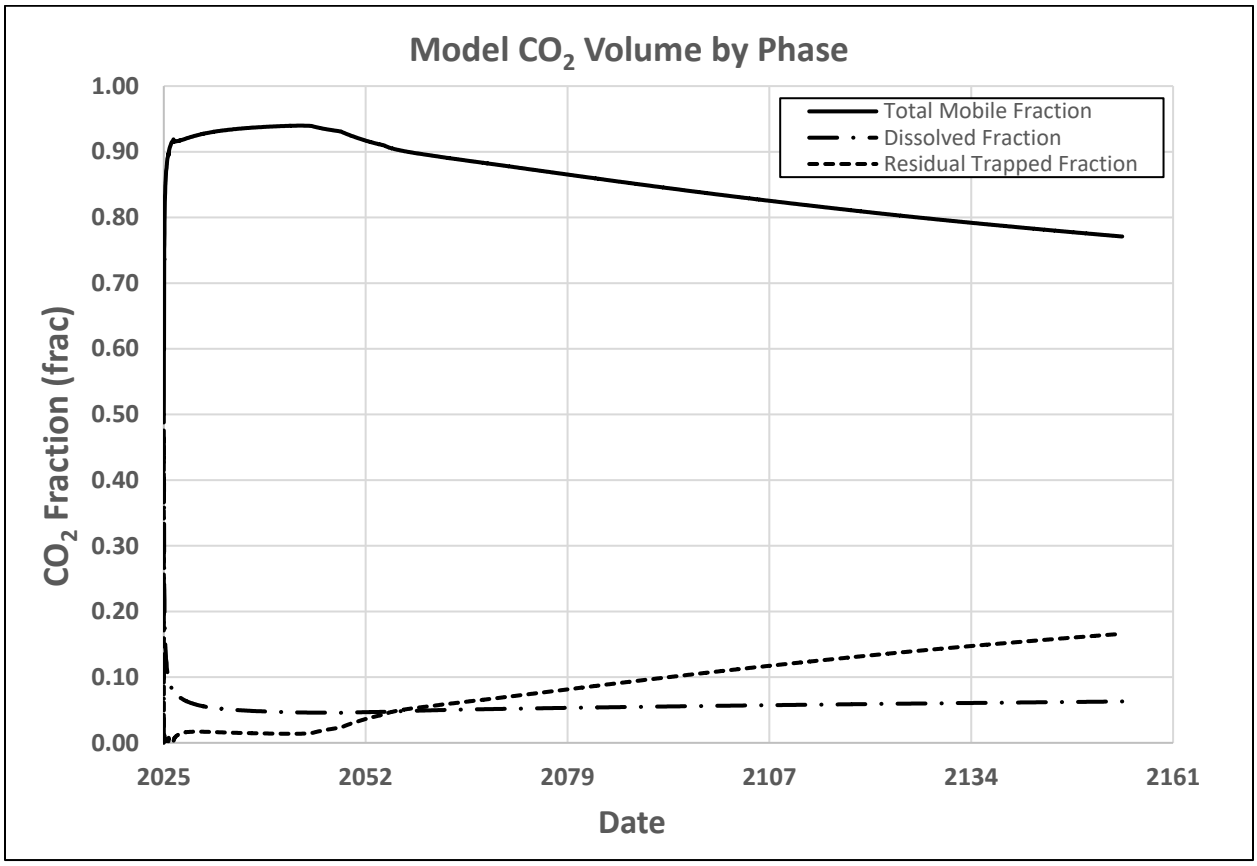



Figure B.24—Modeled fraction of $CO_2$ by phase.

### *B.5.3 Relative Permeability and Capillary Pressure*

To account for the interference of two immiscible fluids in the pore space following the start of $CO_2$ injection, relative permeability curves are derived from the available literature including (Benson and Pini 2015). Two phase relative permeability curves for water are loaded into the simulation model as a function of water saturation and water relative permeability. Supercritical $CO_2$ is loaded as a function of gas saturation, gas relative permeability. Drainage relative permeability curves are used to model the injection period where non-wetting $CO_2$ displaces the wetting phase which is the formation brine. Similarly, imbibition relative permeability curves are

used to model the process where wetting phase displaces the non-wetting phase, a process which typically takes place when injection stops. At the time of this writing, site-specific core data were collected at the Juniper M-1, but relative permeability testing was not complete. Relative permeability was derived from (Benson and Pini 2015). The published values provide a reasonable estimate based on the current understanding of the reservoir. Relative permeability curves shown in Figure B.25 are derived from the data presented in Figure B.26 and used as inputs to the dynamic simulation model but require further calibration following data analysis. These estimated parameters will likely have an impact on future reevaluations of the model.

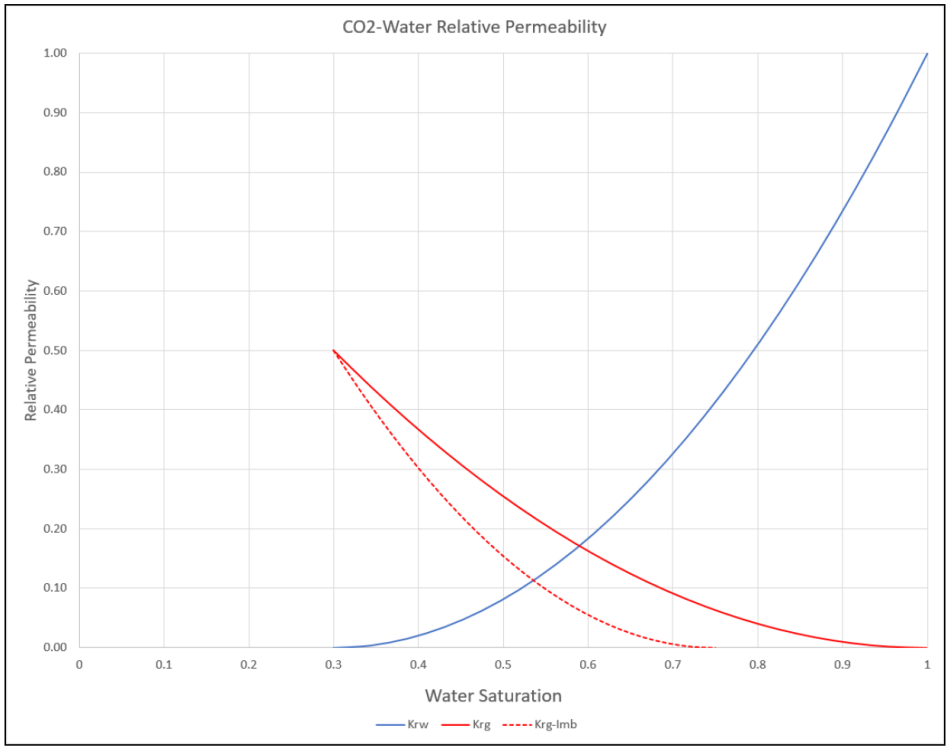



Figure B.25—Supercritical $CO_2$-water relative permeability curves (Benson et al. 2015)

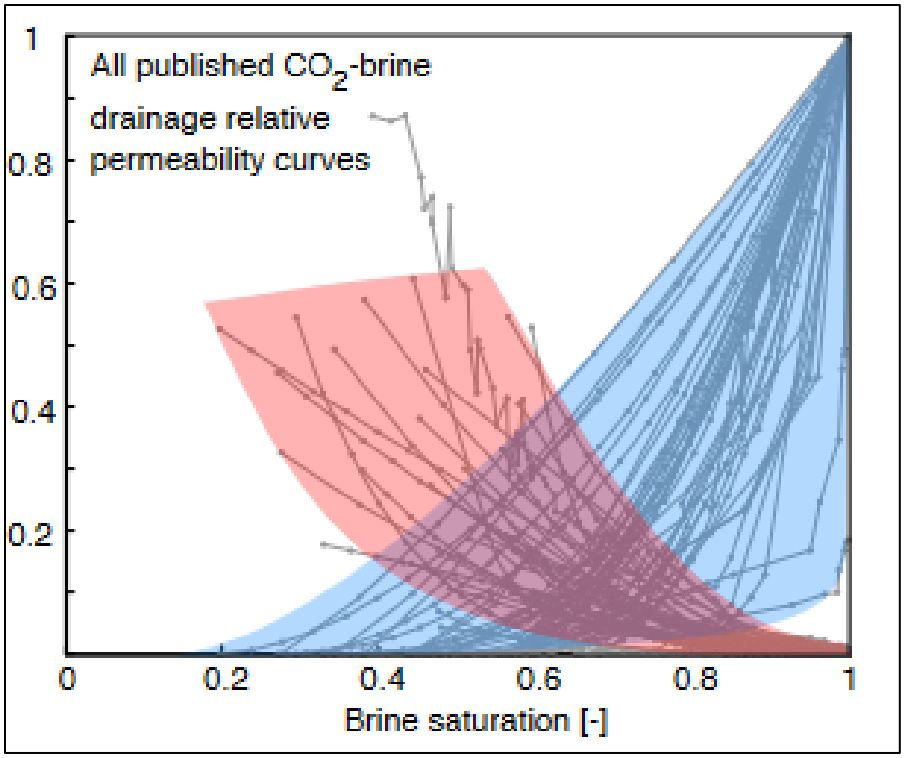


Figure B.26—$CO_2$-water relative permeability curves (Benson et al. 2015).

### *B.5.4 Boundary Conditions*

The initial conditions for the simulation model are assumed to be in a pseudo-infinite acting reservoir fully saturated with brine water. To simulate a pseudo-infinite acting boundary and, pinch out of the Lyons Formation the red grid blocks shown in Figure B.27 at the east and west edges of the model are adjusted with an introduction of a volume multiplier equal to 739 times the volume of the blue grid blocks in the interior of the model (Figure B.27). The volume multiplier simulates 70 miles of additional pore volume 70 miles from the model edge of connected pore space.

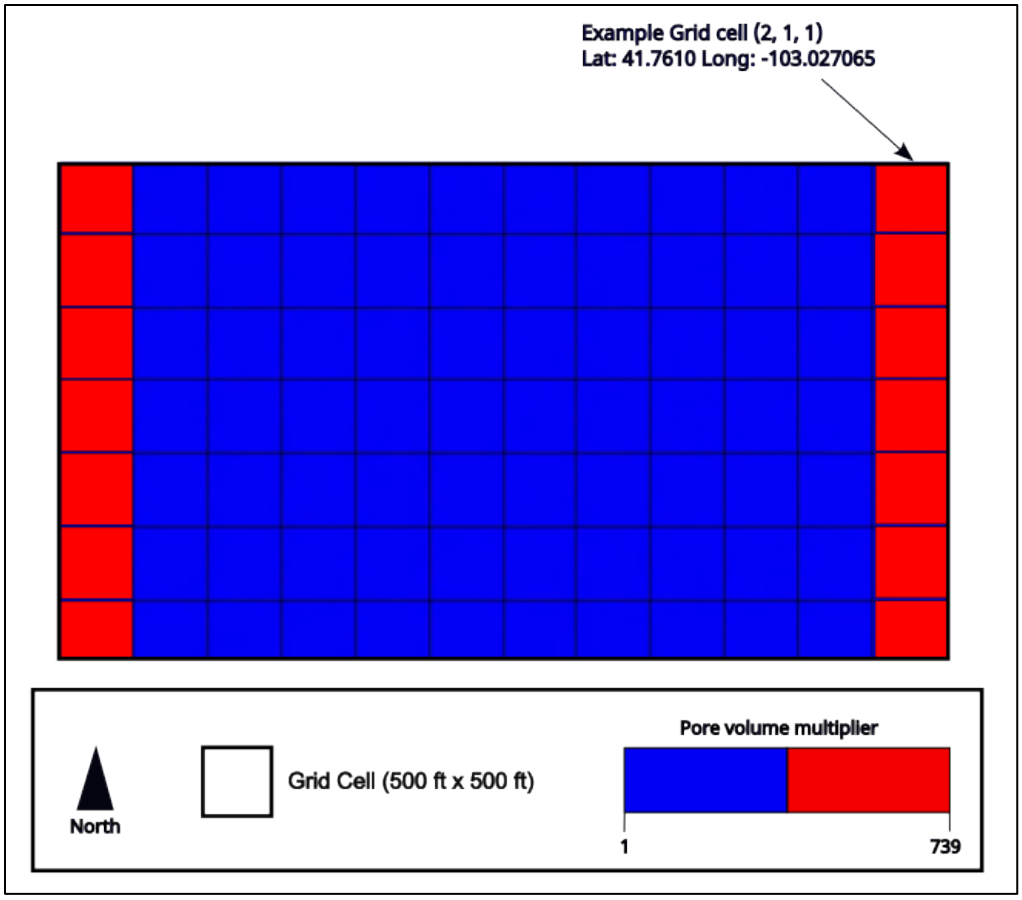


Figure B.27—Pore volume multiplier used to simulate a pseudo-infinite acting boundary.

### *B.5.5 Well Assumptions*

To model the cumulative effect of $CO_2$ injection on the reservoir, six $CO_2$ injectors and eight SWD wells (Table B.2) were incorporated into the reginal EWS Hub simulation. The modeled $CO_2$ injection wells were grouped and limited to a combined injection rate of 5.1 MMT/yr. The per well injection rate was limited to 1.5 MMT/year and a maximum bottom hole injection pressure gradient of 0.51 psi/ft. This pressure constraint was calculated from the fracture gradient with a 10% safety factor as required by regulation. As discussed earlier in *Fracture Gradient Discussion*, here in *Section C.2.3*.

Table B.2—List of saltwater disposal wells included in the dynamic model.

| Well Name | UWI | Well Type | State | Latitude | Longitude |
|---|---|---|---|---|---|
| MARSHALL 31 SWD | 261052273500 | SWD | NE | 41.222543 | -103.559212 |
| NGL C9 SWD | 051234019400 | SWD | CO | 40.835985 | -104.159846 |
| NGL C9C SWD | 051234077100 | SWD | CO | 40.820625 | -104.161956 |
| RAZOR 21 SWD 1 | 051234077700 | SWD | CO | 40.823872 | -103.868780 |
| RAZOR 26J-2633L SWD | 051233749500 | SWD | CO | 40.808565 | -103.829466 |
| SIMBA 1-06 SWD | 051233103500 | SWD | CO | 40.955647 | -104.361223 |
| SWD C8A | 051233285800 | SWD | CO | 40.893947 | -104.335021 |
| WILDHORSE 16-13L SWD | 051233737400 | SWD | CO | 40.748580 | -103.989879 |

To calculate the tubing head pressure, tubing inner diameter, relative roughness, setting depth, and wellhead temperature for the Spirea I-1 were used as inputs to Aziz 1972 correlation for calculating the pressure drop in wells producing oil and gas. Wellhead temperature was assumed to be 60°F based on the historical-average ambient surface temperature. These inputs are summarized in Table B.3.

Table B.3—Wellbore model assumptions

| Assumption | Units | Value |
|---|---|---|
| Max Group Injection Rate | MMT/yr | 5.1 |
| Max Injection Rate | MMT/yr | 1.5 |
| Pressure Constraint | psi/ft | 0.51 |
| Injection Period | yrs | 24 |
| Nominal Tubing OD | inch | 4.5 |
| Tubing ID | inch | 4.0 |
| Tubing Setting Depth | ft | 9,452 |
| Wellhead Temperature | °F | 60 |

## B.6 Simulation Results

The simulation outlined in this document is run with the primary intention of delineating the plume size and AoR as a function of the pressure increase in the reservoir resulting from the injection of $CO_2$. The pressure buildup is evaluated as the rise in reservoir pressure, or pressure gradient across the perforated interval. Figure B.28 shows the maximum pressure buildup and maximum pressure gradient seen within the reservoir through the modeled timeframe. The maximum modeled pressure buildup is 1,297 psi which does not exceed 90% of the calculated fracture pressure. In addition to calculating the plume size and AoR, the simulation demonstrates the optimized storage capacity of the reservoir (Table B.4) with a cumulative mass of $CO_2$ injected at the Spirea I-1 location of 10.6 MMT (Figure B.30).

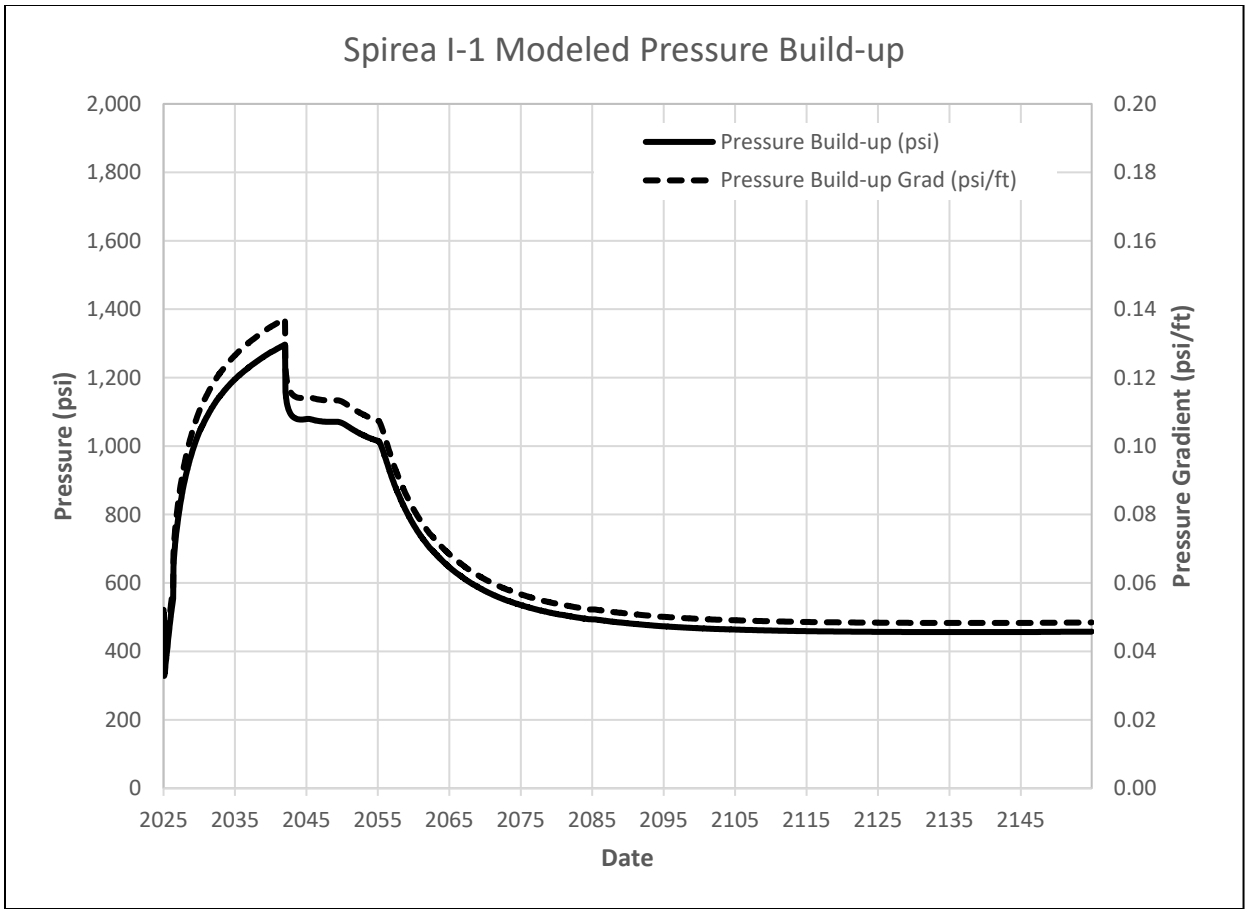



Figure B.28—Reservoir pressure build up resulting from the injection of $CO_2$.

The $CO_2$ injection rate for the EWS Hub was modeled with both a group maximum rate and per well maximum rate. The group rate was constrained to 5.1 MMT/year and a per-well maximum rate of 1.5 MMT/year. As the offset wells to Spirea I-1 in the EWS Hub reach the end of injection, additional volume is then allocated in the model to the Spirea I-1. As shown in Figure B.29 the maximum modeled bottom hole pressure reaches 4,509 psi which is 337 psi less than the constraint pressure of 4,846 psi. The constraint pressure was calculated as 90% of the fracture pressure outlined in *Section B.5.1.2*. Also shown in Figure B.29 is the calculated tubing head pressure, which reaches a maximum pressure of 1,597 psi.

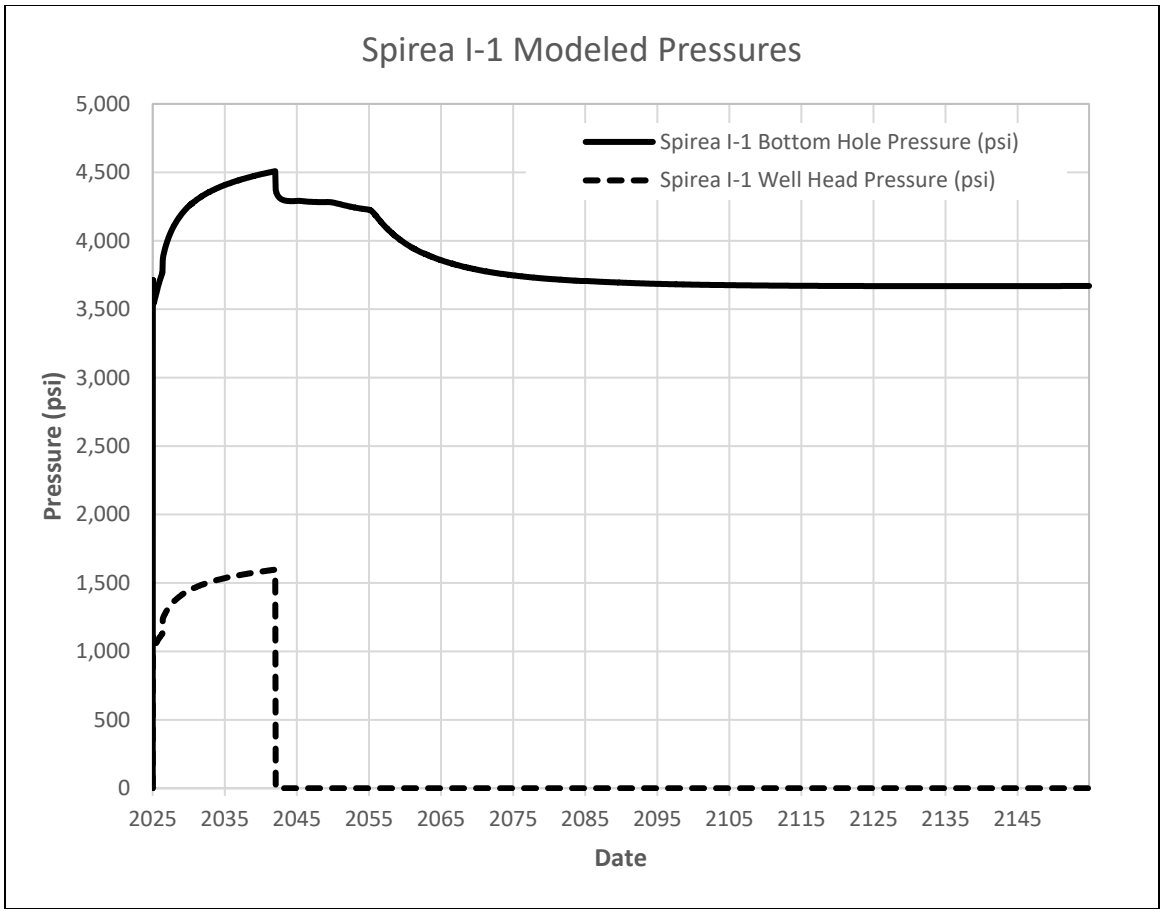


Figure B.29—Spirea I-1 modeled well head pressure and bottom hole pressure.

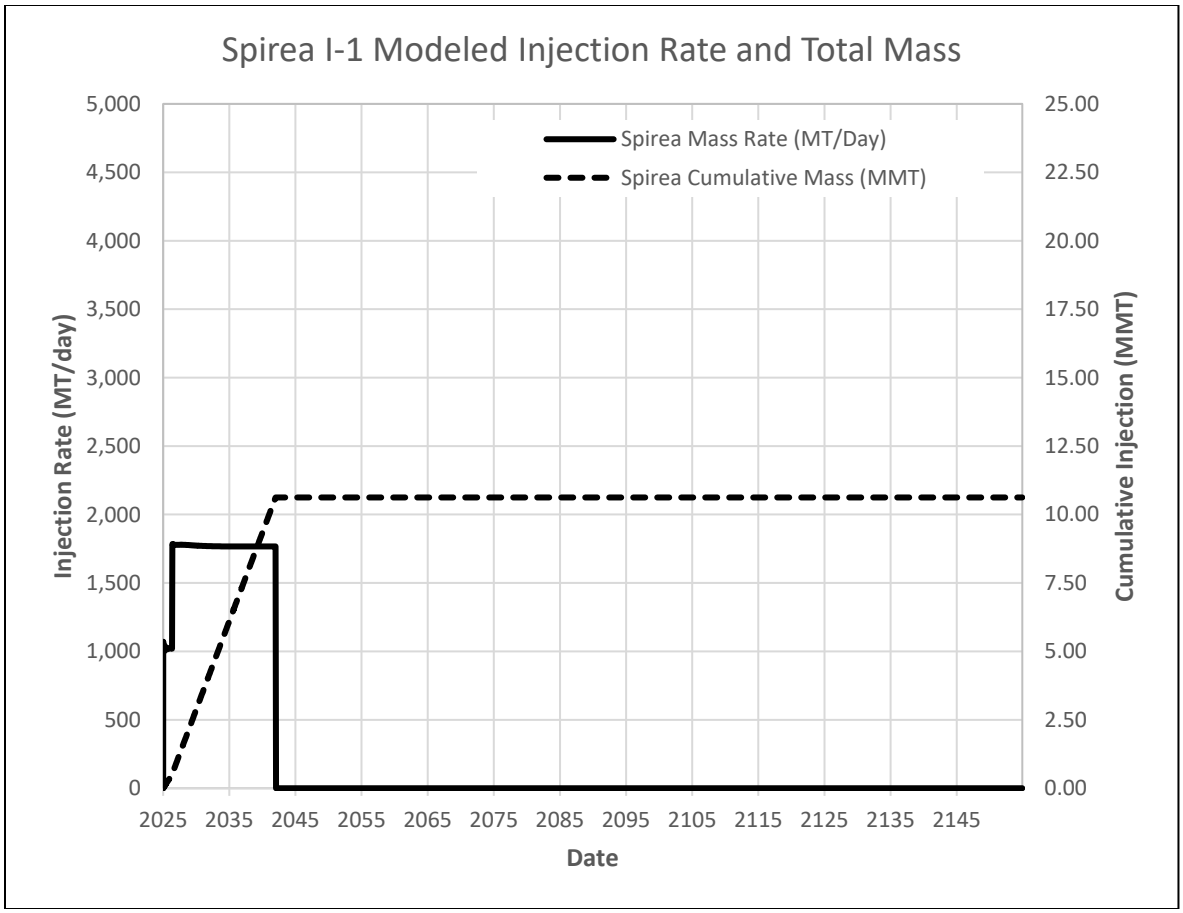


Figure B.30—Spirea I-1 modeled $CO_2$ injection rate and cumulative injection mass.

Following the end of injection, the modeled bottom hole pressure drops and begins to return to in situ conditions as shown in Figure B.31. The final pressure observed within the injection zone in the model is 3,670 psi. Table B.4 summarizes the annual injection rates and pressures through the modeled timeframe.

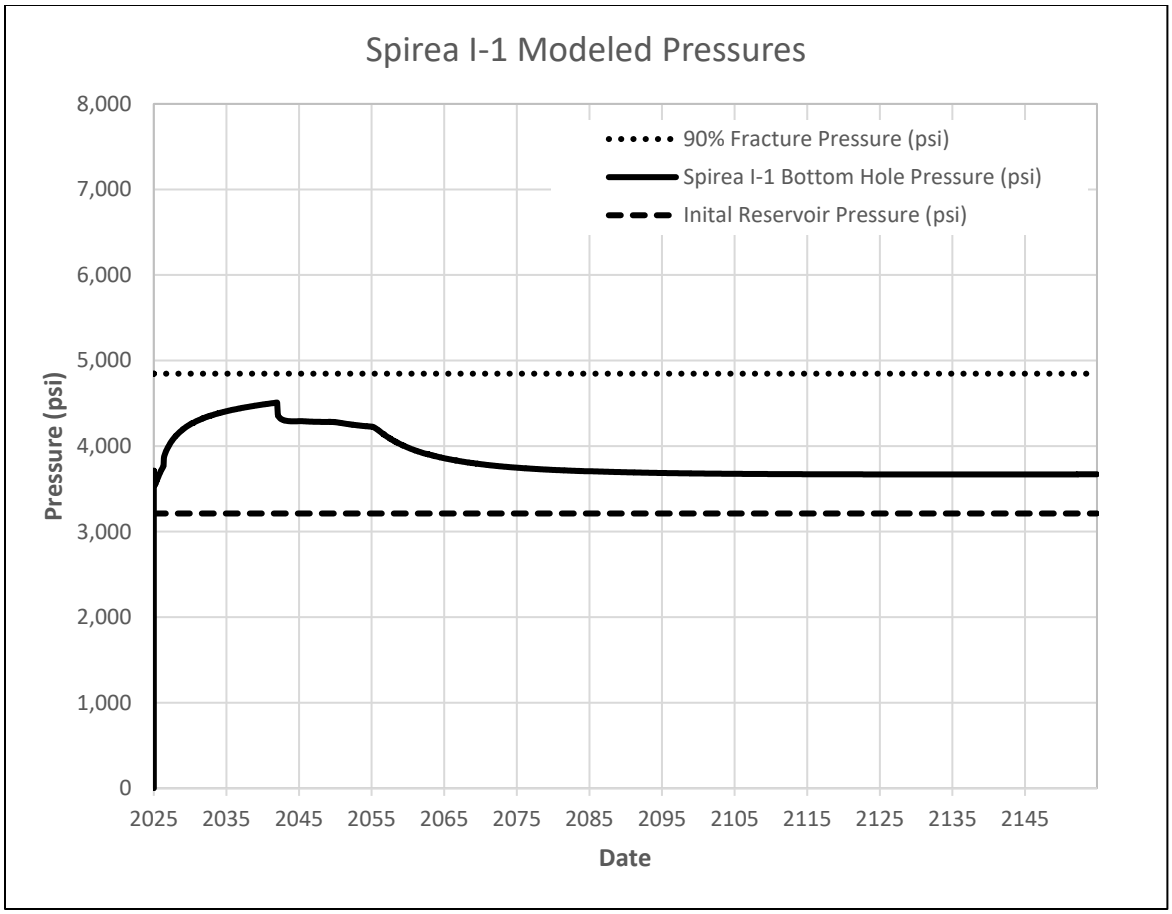


Figure B.31—Spirea I-1 pressure drop after the end of injection.

Table B.4—Spirea I-1 dynamic simulation model outputs.

| Year | $CO_2$ Mass Injection Rate | $CO_2$ Cumulative Injected Mass | Bottom-hole Pressure | Well Head Pressure (psi) |
|---|---|---|---|---|
| **2025** | 1,001 | 0.37 | 3,619 | 1,064 |
| **2026** | 1,585 | 0.91 | 3,867 | 1,223 |
| **2027** | 1,779 | 1.57 | 4,055 | 1,335 |
| **2028** | 1,778 | 2.22 | 4,153 | 1,388 |
| **2029** | 1,775 | 2.83 | 4,223 | 1,428 |
| **2030** | 1,772 | 3.52 | 4,271 | 1,455 |
| **2031** | 1,770 | 4.13 | 4,315 | 1,480 |
| **2032** | 1,768 | 4.77 | 4,348 | 1,500 |
| **2033** | 1,768 | 5.45 | 4,373 | 1,515 |
| **2034** | 1,767 | 6.10 | 4,396 | 1,529 |
| **2035** | 1,767 | 6.74 | 4,417 | 1,541 |
| **2036** | 1,766 | 7.39 | 4,436 | 1,553 |
| **2037** | 1,766 | 8.02 | 4,450 | 1,561 |
| **2038** | 1,766 | 8.68 | 4,466 | 1,571 |
| **2039** | 1,766 | 9.32 | 4,479 | 1,579 |
| **2040** | 1,766 | 9.95 | 4,491 | 1,586 |

| Year | $CO_2$ Mass Injection Rate | $CO_2$ Cumulative Injected Mass | Bottom-hole Pressure | Well Head Pressure (psi) |
|---|---|---|---|---|
| **2041** | 1,767 | 10.58 | 4,503 | 1,593 |
| **2042** | 88 | 10.62 | 4,341 | 80 |
| **2043** | 0 | 10.62 | 4,294 | 0 |
| **2044** | 0 | 10.62 | 4,290 | 0 |
| **2045** | 0 | 10.62 | 4,291 | 0 |
| **2046** | 0 | 10.62 | 4,286 | 0 |
| **2047** | 0 | 10.62 | 4,283 | 0 |
| **2048** | 0 | 10.62 | 4,283 | 0 |
| **2049** | 0 | 10.62 | 4,282 | 0 |
| **2050** | 0 | 10.62 | 4,274 | 0 |
| **2051** | 0 | 10.62 | 4,261 | 0 |
| **2052** | 0 | 10.62 | 4,249 | 0 |
| **2053** | 0 | 10.62 | 4,240 | 0 |
| **2054** | 0 | 10.62 | 4,231 | 0 |
| **2055** | 0 | 10.62 | 4,209 | 0 |
| **2056** | 0 | 10.62 | 4,146 | 0 |
| **2057** | 0 | 10.62 | 4,088 | 0 |
| **2058** | 0 | 10.62 | 4,045 | 0 |
| **2059** | 0 | 10.62 | 4,003 | 0 |
| **2060** | 0 | 10.62 | 3,967 | 0 |
| **2061** | 0 | 10.62 | 3,942 | 0 |
| **2062** | 0 | 10.62 | 3,907 | 0 |
| **2063** | 0 | 10.62 | 3,887 | 0 |
| **2064** | 0 | 10.62 | 3,866 | 0 |
| **2065** | 0 | 10.62 | 3,850 | 0 |
| **2066** | 0 | 10.62 | 3,833 | 0 |
| **2067** | 0 | 10.62 | 3,821 | 0 |
| **2068** | 0 | 10.62 | 3,805 | 0 |
| **2069** | 0 | 10.62 | 3,794 | 0 |
| **2070** | 0 | 10.62 | 3,784 | 0 |
| **2071** | 0 | 10.62 | 3,774 | 0 |
| **2072** | 0 | 10.62 | 3,765 | 0 |
| **2073** | 0 | 10.62 | 3,758 | 0 |
| **2074** | 0 | 10.62 | 3,751 | 0 |
| **2075** | 0 | 10.62 | 3,745 | 0 |
| **2076** | 0 | 10.62 | 3,739 | 0 |
| **2077** | 0 | 10.62 | 3,733 | 0 |
| **2078** | 0 | 10.62 | 3,728 | 0 |
| **2079** | 0 | 10.62 | 3,723 | 0 |
| **2080** | 0 | 10.62 | 3,720 | 0 |
| **2081** | 0 | 10.62 | 3,716 | 0 |
| **2082** | 0 | 10.62 | 3,713 | 0 |

| Year | $CO_2$ Mass Injection Rate | $CO_2$ Cumulative Injected Mass | Bottom-hole Pressure | Well Head Pressure (psi) |
|---|---|---|---|---|
| **2083** | 0 | 10.62 | 3,709 | 0 |
| **2084** | 0 | 10.62 | 3,706 | 0 |
| **2085** | 0 | 10.62 | 3,705 | 0 |
| **2086** | 0 | 10.62 | 3,702 | 0 |
| **2087** | 0 | 10.62 | 3,700 | 0 |
| **2088** | 0 | 10.62 | 3,697 | 0 |
| **2089** | 0 | 10.62 | 3,695 | 0 |
| **2090** | 0 | 10.62 | 3,693 | 0 |
| **2091** | 0 | 10.62 | 3,692 | 0 |
| **2092** | 0 | 10.62 | 3,689 | 0 |
| **2093** | 0 | 10.62 | 3,687 | 0 |
| **2094** | 0 | 10.62 | 3,686 | 0 |
| **2095** | 0 | 10.62 | 3,685 | 0 |
| **2096** | 0 | 10.62 | 3,683 | 0 |
| **2097** | 0 | 10.62 | 3,682 | 0 |
| **2098** | 0 | 10.62 | 3,681 | 0 |
| **2099** | 0 | 10.62 | 3,680 | 0 |
| **2100** | 0 | 10.62 | 3,679 | 0 |
| **2101** | 0 | 10.62 | 3,678 | 0 |
| **2102** | 0 | 10.62 | 3,677 | 0 |
| **2103** | 0 | 10.62 | 3,677 | 0 |
| **2104** | 0 | 10.62 | 3,676 | 0 |
| **2105** | 0 | 10.62 | 3,675 | 0 |
| **2106** | 0 | 10.62 | 3,675 | 0 |
| **2107** | 0 | 10.62 | 3,674 | 0 |
| **2108** | 0 | 10.62 | 3,674 | 0 |
| **2109** | 0 | 10.62 | 3,673 | 0 |
| **2110** | 0 | 10.62 | 3,673 | 0 |
| **2111** | 0 | 10.62 | 3,672 | 0 |
| **2112** | 0 | 10.62 | 3,672 | 0 |
| **2113** | 0 | 10.62 | 3,672 | 0 |
| **2114** | 0 | 10.62 | 3,671 | 0 |
| **2115** | 0 | 10.62 | 3,671 | 0 |
| **2116** | 0 | 10.62 | 3,671 | 0 |
| **2117** | 0 | 10.62 | 3,670 | 0 |
| **2118** | 0 | 10.62 | 3,670 | 0 |
| **2119** | 0 | 10.62 | 3,670 | 0 |
| **2120** | 0 | 10.62 | 3,670 | 0 |
| **2121** | 0 | 10.62 | 3,670 | 0 |
| **2122** | 0 | 10.62 | 3,669 | 0 |
| **2123** | 0 | 10.62 | 3,669 | 0 |
| **2124** | 0 | 10.62 | 3,669 | 0 |

| Year | $CO_2$ Mass Injection Rate | $CO_2$ Cumulative Injected Mass | Bottom-hole Pressure | Well Head Pressure (psi) |
|---|---|---|---|---|
| **2125** | 0 | 10.62 | 3,669 | 0 |
| **2126** | 0 | 10.62 | 3,669 | 0 |
| **2127** | 0 | 10.62 | 3,669 | 0 |
| **2128** | 0 | 10.62 | 3,669 | 0 |
| **2129** | 0 | 10.62 | 3,669 | 0 |
| **2130** | 0 | 10.62 | 3,669 | 0 |
| **2131** | 0 | 10.62 | 3,669 | 0 |
| **2132** | 0 | 10.62 | 3,668 | 0 |
| **2133** | 0 | 10.62 | 3,668 | 0 |
| **2134** | 0 | 10.62 | 3,668 | 0 |
| **2135** | 0 | 10.62 | 3,668 | 0 |
| **2136** | 0 | 10.62 | 3,668 | 0 |
| **2137** | 0 | 10.62 | 3,668 | 0 |
| **2138** | 0 | 10.62 | 3,668 | 0 |
| **2139** | 0 | 10.62 | 3,668 | 0 |
| **2140** | 0 | 10.62 | 3,668 | 0 |
| **2141** | 0 | 10.62 | 3,668 | 0 |
| **2142** | 0 | 10.62 | 3,668 | 0 |
| **2143** | 0 | 10.62 | 3,668 | 0 |
| **2144** | 0 | 10.62 | 3,669 | 0 |
| **2145** | 0 | 10.62 | 3,669 | 0 |
| **2146** | 0 | 10.62 | 3,669 | 0 |
| **2147** | 0 | 10.62 | 3,669 | 0 |
| **2148** | 0 | 10.62 | 3,669 | 0 |
| **2149** | 0 | 10.62 | 3,669 | 0 |
| **2150** | 0 | 10.62 | 3,669 | 0 |
| **2151** | 0 | 10.62 | 3,669 | 0 |
| **2152** | 0 | 10.62 | 3,669 | 0 |
| **2153** | 0 | 10.62 | 3,670 | 0 |
| **2154** | 0 | 10.62 | 3,670 | 0 |
| **2155** | 0 | 10.62 | 3,670 | 0 |

## B.7 Stabilized Plume

Juniper M-1 core data is still being analyzed, but preliminary results indicate that the injection and confining zone thickness, porosity and permeability values in the model are similar to the measured core and log values in the Juniper M-1 well. Because the modeled parameters are comparable to the Juniper M-1 well, High Plains plans to update the model after drilling Juniper I-1 once additional site-specific data is acquired. Figure B.33, which shows the lateral and vertical saturation extents of the $CO_2$ plume at the end of the PISC period. Figure B.32 below shows the

change in $CO_2$ plume radius as a function of time. Notably, this change in radius stabilizes after the end of injection and becomes minimal after 2055.

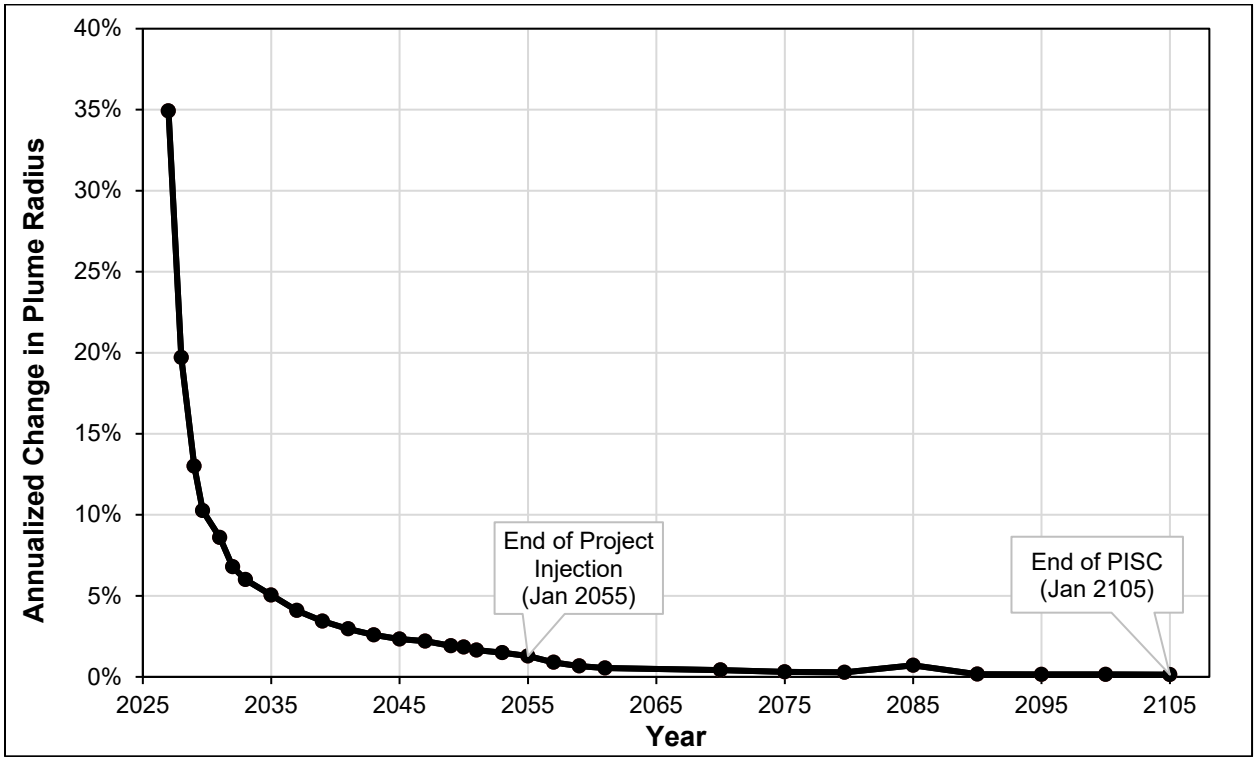



Figure B.32—Annualized percent change in plume radius from the first year of injection through the end of post-injection site care (site closure). Utilizes the plume area with saturation greater than 2% and assumes the area is a circle.

Figure B.33 below shows the vertical and lateral distribution of the $CO_2$ plume at the end of the PISC period in 2105. Note that the $CO_2$ plume laterally migrates along an up-dip trend (to the southeast) and vertically develops with the widest expanse along the top of the injection zone.

It is expected that formation fluid migration will occur during the life of the Project as the injection zone pressures change due to $CO_2$ injection. This migration will be governed by the same elements that control the migration of injected $CO_2$ (e.g., structural dip, reservoir properties such as facies, porosity and permeability distribution and changes in injection zone pressure). These elements are discussed in the application narrative.

The maximum extent of the plume was characterized by identifying all grid blocks in model year 2105 with a $CO_2$ saturation of 2% or greater. The cross sections shown in Figure B.33 (SW-NE and SE-NW, respectively) were constructed at the wellbore and demonstrate the extent of the plume in model year 2105 at the end of the PISC timeframe. The plume primarily extends to the southeast due to the structural dip.

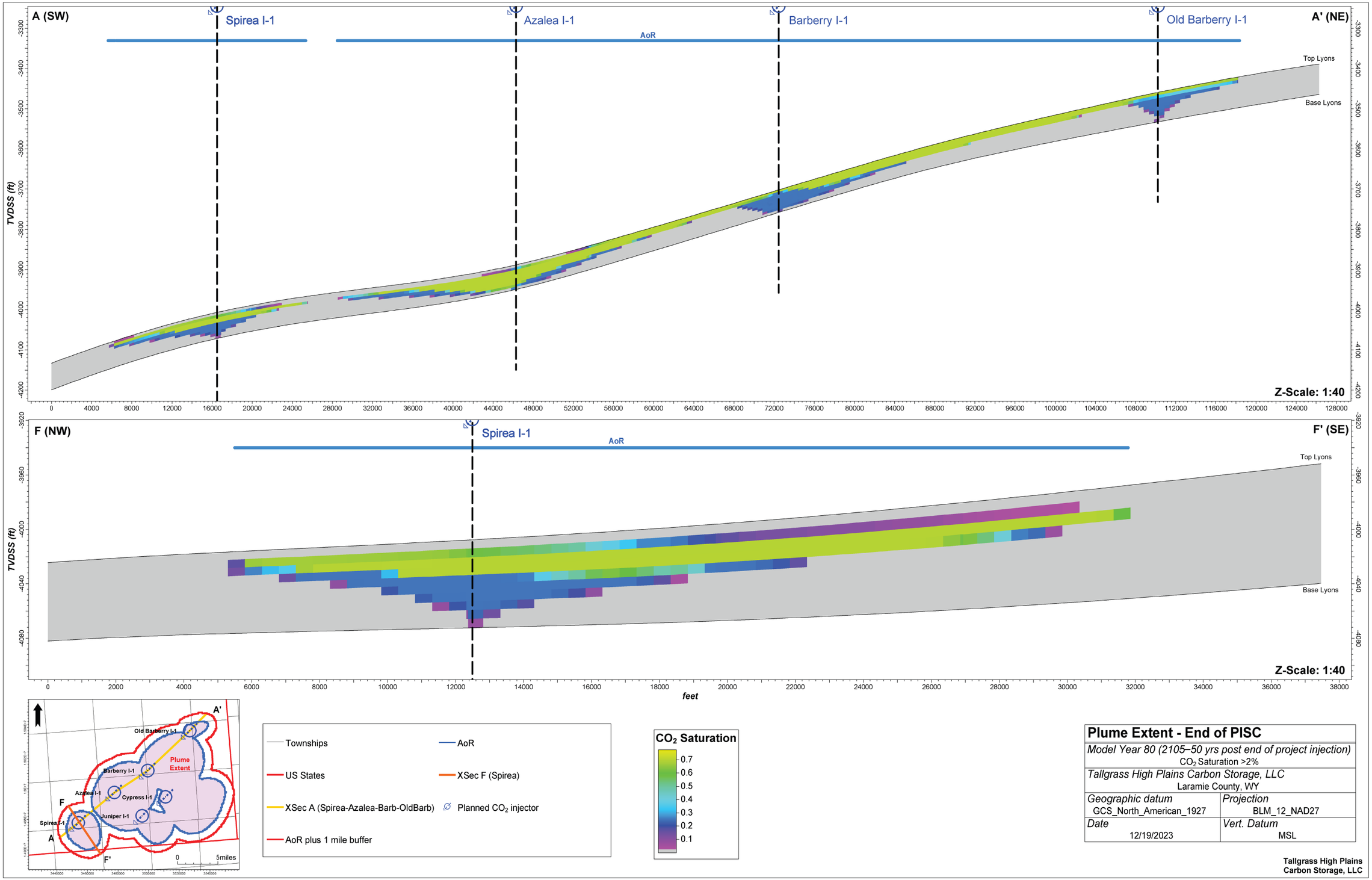



Figure B.33—Two orthogonal cross sections through the $CO_2$ plume model at the proposed location of the Spirea I-1 injection well showing modeled $CO_2$ saturation in 2105—the end of the PISC period (site closure). Saturation is only shown where greater than 2%.

## B.8 Delineation of AoR

To calculate the extent of the AoR, the maximum increase in the reservoir pressure resulting from the injection of supercritical $CO_2$ (Figure B.35) was evaluated at all points within the model domain, and compared to the critical pressure calculated in Equation B.7. At no point in the model domain is there sufficient hydraulic potential to lift fluid from the injection zone into the Fox Hills (lowermost confirmed USDW). The AoR was there for delineated by the extent of the modeled $CO_2$ saturation evaluated at a 2% cutoff.

Per WYDEQ Chapter 24 **§10(b)(xii)**, an additional one-mile radius was added to the plume. This radius provides an extra buffer for plume and pressure dissipation. Monitoring equipment, as discussed in *Section 5 – Testing and Monitoring Plan*, will detect deviations in plume size and shape. Any deviations will be evaluated, and the model updated accordingly.




Figure B.34—Aerial depiction of $CO_2$ plume.

## B.9 Critical-Threshold Pressure-Increase Estimation in Injection Well

The methodology for finding critical pressure was sourced from the EPA's Underground Injection Control (UIC) Program Class VI Well Area of Review Evaluation and Corrective Action Guidance, for calculations based on displacing fluid initially present in the borehole in the hydrostatic case. The critical pressure increase is defined as the pressure buildup needed for the hydraulic head of the formation fluid in the injection zone to be equal to or greater than the hydraulic head of the USDW.

The base of the USDW is expected to be at 1,056 ft as observed on offset logs and at the Juniper M-1. The critical pressure was calculated for the predicted top of the injection interval for the Spirea I-1 well, which is estimated to be at 9,447 ft. The fluid within the USDW was assumed to be freshwater with a salinity of 7,000 mg/L TDS, and a density of 62.8 lb/ft3. The fluid in the injection zone is assumed to be brine with 230,000 mg/L TDS, and a density 76.8 lb/ft3. As shown in Figure B.18, the hydrostatic gradient for the region is 0.34 psi/ft. A gradient of 0.3 psi/ft is used for the lowermost USDW. A summary of the calculation inputs is included in Table B.5.

Table B.5—Inputs for critical pressure calculation.

| Input | Units | Value |
|---|---|---|
| Depth to Base of USDW | ft | 1,056 |
| Depth to Top of Injection Zone | ft | 9,447 |
| Temp in USDW | °F | 90 |
| Temp in Injection Zone | °F | 256 |
| Salinity in USDW | mg/L | 7,000 |
| Salinity in Injection Zone | mg/L | 230,000 |
| Fluid Density in USDW | $lb/ft^3$ | 62.8 |
| Fluid Density in Injection Zone | $lb/ft^3$ | 76.8 |
| Initial Pressure at Base of USDW | psi | 317 |
| Initial Pressure at Top of Injection Zone | psi | 3,212 |

The calculations for the critical pressure rise ($\Delta P_c$) are as follows.

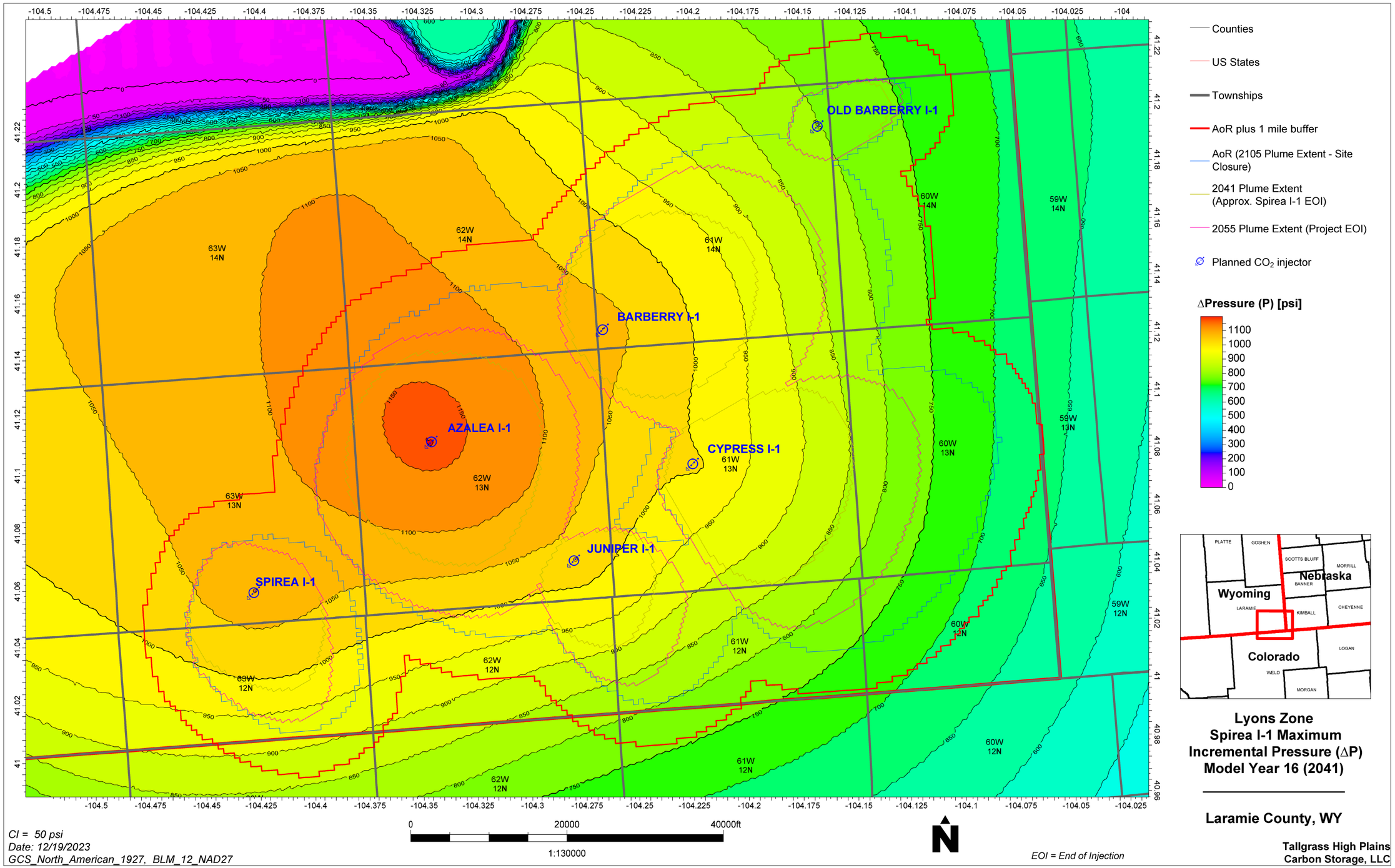
Equation B.7—Critical pressure rise equation

$$\Delta P_c = P_{usdw} + (dz_i - dz_{usdw}) * SG_i * 0.433 \ - P_i$$
$$\Delta P_c = 317 + (9{,}447 - 1{,}056) * 1.23 * 0.433 - 3{,}312$$
$$\Delta P_c = 1{,}402\ psi$$

$P_{usdw} = Hydrostatic\ Pressure\ at\ the\ base\ USDW\ (psi)$
$dz_i = Depth\ of\ the\ top\ of\ the\ injection\ zone\ (ft)$
$dz_{usdw} = Depth\ of\ the\ base\ of\ the\ USDW\ (ft)$
$SG_i = Specific\ Gravity\ of\ the\ liquid\ in\ the\ injection\ zone$
$P_i = Hydrostatic\ pressure\ at\ the\ top\ of\ the\ injection\ zone\ (psi)$

The critical pressure calculated in Equation B.7 is positive, indicating that the reservoir is underpressured relative to the USDW, and that the reservoir pressure in the Lyons Formation may be safely increased by 1,402 psi without risk of generating sufficient hydraulic potential for fluids to migrate from the injection zone to the USDW.

The maximum increase in reservoir pressure modeled at the Spirea I-1 is 1,297 psi. The modeled increase in pressure across the AoR is 1,311 psi (Figure B.35). At no point in the model domain does is the increase in reservoir pressure sufficient to exceed the critical pressure. The AoR is defined as the extent of the plume where the modeled $CO_2$ saturation is greater than 2%.




**Lyons Zone**
**Spirea I-1 Maximum Incremental Pressure (ΔP)**
**Model Year 16 (2041)**

**Laramie County, WY**

*CI = 50 psi*
*Date: 12/19/2023*
*GCS_North_American_1927, BLM_12_NAD27*

*EOI = End of Injection*

**Tallgrass High Plains Carbon Storage, LLC**

Figure B.35—Area of review incremental pressure map. The maximum increase in pressure (ΔP) in the injection zone (Lyons Formation) at the Spirea I-1 location is shown in model year 16 (2041). At no area in the model domain does incremental pressure reach 1,402 psi, the critical threshold pressure.

## B.10 Wells Within the AoR

An investigation was conducted to evaluate wellbores drilled within the determined AoR. In total, 57 oil-and-gas wells (52 of which are plugged and abandoned) and 597 water wells were found (Table B.6 and Figure B.36). Of these wells, only three penetrate the confining layer within the AoR: Juniper M-1, Fritz 1 and UPRR Palm 1-21. Juniper M-1 is the monitoring well for the EWS hub and was constructed with $CO_2$ resistant material. Fritz 1 and UPRR Palm 1-21 were both drilled and abandoned. They contain no production casing and have adequate cement plugs over USDWs and pose low to negligible risk. A map of the water wells is shown in Figure B.37 and a list of them is provided in Table B.7.

Table B.6—Area of review well information.

| API Number | Well Name | Latitude (WGS84) | Longitude (WGS84) | Operator | Spud Date | Well Status | Drill Type | Total Vertical Depth | Measured Depth (TD) |
|---|---|---|---|---|---|---|---|---|---|
| 49021050030000 | BREEDEN 1-A | 41.02354 | -104.43768 | HAYES ROBERTSON DRLG CO | 6/20/1950 | DRY HOLE, P & A | V | 5,000 | 5,010 |
| 49021050040000 | BREEDEN 1 | 41.029981 | -104.429365 | WATKINS J N | 11/3/1949 | DRY HOLE, P & A | V | 292 | 292 |
| 49021050060000 | STATE 53 1 | 41.051041 | -104.142931 | SHELL | 7/17/1958 | DRY HOLE, P & A | V | 7,665 | 7,665 |
| 49021050070000 | FARR 1 | 41.058368 | -104.085807 | BRADEN OIL | 7/24/1958 | DRY HOLE, P & A | V | 7,787 | 7,787 |
| 49021050110000 | CULEK 1 | 41.069075 | -104.104708 | WYOMING OIL & DEV CO | 9/28/1959 | DRY HOLE, P & A | V | 7,544 | 7,544 |
| 49021050170000 | MORRITZ 1 | 41.078112 | -104.111715 | WILLIAMS EXPLORATION CO | 9/6/1955 | DRY HOLE, P & A | V | 7,555 | 7,555 |
| 49021050310000 | RUBY SCHACHER 1 | 41.107203 | -104.073475 | BRADEN OIL | 12/20/1955 | DRY HOLE, P & A | V | 7,602 | 7,602 |
| 49021050330000 | FRITZ 1 | 41.136051 | -104.149498 | GINTHER, WARREN & GINTHER | 4/1/1938 | DRY HOLE, P & A | V | 9,015 | 9,015 |
| 49021050340000 | UPRR-ML BASTIAN 1 | 41.141785 | -104.289733 | GROSS TODD | 9/26/1938 | DRY HOLE, P & A | V | 8,018 | 8,031 |
| 49021050350000 | RAUNER 1 | 41.135973 | -104.130366 | CHEVRON | 8/31/1951 | DRY HOLE, P & A | V | 7,756 | 7,756 |
| 49021050370000 | WILHELM 2 | 41.150422 | -104.130134 | C M & W DRILLING | 4/18/1956 | DRY HOLE, P & A | V | 7,480 | 7,480 |
| 49021050390000 | MORRIS 1 | 41.150422 | -104.130134 | C M & W DRILLING | 3/12/1956 | DRY HOLE, P & A | V | 7,449 | 7,449 |
| 49021050420000 | CAMPBELL 1 | 41.14484 | -104.103932 | WYOMING OIL & DEV CO | 7/1/1939 | DRY HOLE, P & A | V | 7,418 | 7,418 |
| 49021050440000 | CAMPBELL 1 | 41.150305 | -104.111014 | C M & W DRILLING | 12/4/1943 | DRY HOLE, P & A | V | 7,465 | 7,469 |
| 49021050450000 | WILHELM 1 | 41.147693 | -104.124221 | PAR PACIFIC HOLDINGS | 10/1/1955 | OIL, P & A | V | 7,462 | 7,462 |
| 49021050480000 | WW DAVIS 1 | 41.14514 | -104.11777 | SUNRAY O&G | 4/19/1956 | DRY HOLE, P & A | V | 8,669 | 8,670 |
| 49021050540000 | FORNSTROM 1 | 41.170152 | -104.108321 | WYOMING OIL & DEV CO | 8/31/1955 | DRY HOLE, P & A | V | 7,434 | 7,434 |
| 49021050550000 | ROHRBAUGH 1 | 41.165099 | -104.225558 | SLOSS JAMES P | 8/2/1955 | DRY HOLE, P & A | V | 7,857 | 7,857 |
| 49021050580000 | GROSS 3-17 | 41.173732 | -104.103457 | CENTRAL OPERATING INC | 8/21/1955 | OIL, P & A | V | 7,430 | 7,430 |
| 49021050600000 | ED PRESSER 1 | 41.179401 | -104.167961 | LEFTWICH J D | 1/23/1954 | DRY HOLE, P & A | V | 7,740 | 7,740 |
| 49021050650000 | BARKELL 1 | 41.177596 | -104.156025 | TRUE COMPANIES | 10/5/1955 | DRY HOLE, P & A | V | 7,594 | 7,594 |
| 49021050660000 | GROSS-WILKERSON 1 | 41.179354 | -104.148853 | NICKLE L L | 9/16/1955 | DRY HOLE, P & A | V | 7,540 | 7,540 |
| 49021050690000 | GROSS-WILKERSON 1 | 41.179203 | -104.110573 | PURE OIL CO | 4/17/1950 | DRY HOLE, P & A | V | 7,386 | 7,387 |
| 49021050700000 | GROSS-WILKINSON 2 | 41.179203 | -104.110573 | PURE OIL CO | 10/6/1955 | DRY HOLE, P & A | V | 7,413 | 7,413 |
| 49021050770000 | ST JOHN 1 | 41.193866 | -104.186895 | JOHNSON D E A INC | 12/27/1955 | DRY HOLE, P & A | V | 7,690 | 7,701 |

| API Number | Well Name | Latitude (WGS84) | Longitude (WGS84) | Operator | Spud Date | Well Status | Drill Type | Total Vertical Depth | Measured Depth (TD) |
|---|---|---|---|---|---|---|---|---|---|
| 49021050780000 | WISROTH 1 | 41.188272 | -104.101786 | BRADEN OIL | 9/27/1963 | DRY HOLE, P & A | V | 7,430 | 7,430 |
| 49021050800000 | GROSS 1 | 41.198937 | -104.093523 | MCDERMOTT J RAY & | 6/20/1947 | DRY HOLE, P & A | V | 7,403 | 7,403 |
| 49021050810000 | WILKINSON 1 | 41.20813 | -104.110154 | WESTLAND ENERGY | 10/25/1952 | DRY HOLE, P & A | V | 7,625 | 7,625 |
| 49021050820000 | CG WISROTH 1 | 41.20798 | -104.090997 | PURE OIL CO | 9/2/1957 | DRY HOLE, P & A | V | 7,414 | 7,414 |
| 49021050850000 | GH PHELPS 1 | 41.222463 | -104.090855 | GROSS TODD | 3/9/1956 | DRY HOLE, P & A | V | 7,450 | 7,450 |
| 49021050860000 | MORITZ FLAY 1 | 41.222646 | -104.129159 | MIDWEST OIL CORP. | 11/19/1955 | DRY HOLE, P & A | V | 7,445 | 7,570 |
| 49021052450000 | GROSS-WILKINSON 3-A | 41.188328 | -104.097903 | C & M OIL CO | 2/9/1966 | OIL, SHUT-IN | V | 7,434 | 7,434 |
| 49021052530000 | WISROTH RANCH 2 | 41.192064 | -104.102504 | BRADEN OIL | 10/5/1966 | DRY HOLE, P & A | V | 7,407 | 7,407 |
| 49021052570000 | GROSS-WILKINSON 1-A | 41.18811 | -104.098142 | WYOMING WESTERN OIL | 7/22/1962 | DRY HOLE, P & A | V | 7,347 | 7,347 |
| 49021052580000 | GROSS-WILLARD 1 | 41.195427 | -104.093567 | CHAMPION VENTURES INC | 11/24/1962 | DRY HOLE, P & A | U | 7,426 | - |
| 49021053080000 | GROSS-WILLARD 1 | 41.166427 | -104.113194 | CHAMPLIN PETROLEUM | 11/24/1962 | DRY HOLE, P & A | U | - | 7,423 |
| 49021200540000 | MORITZ BROTHERS 1 | 41.098036 | -104.104321 | GROSS TODD | 4/1/1969 | DRY HOLE, P & A | V | 7,700 | 7,700 |
| 49021200610000 | PROSSER 1 | 41.159578 | -104.170609 | GROSS TODD | 7/9/1969 | DRY HOLE, P & A | V | 7,682 | 7,682 |
| 49021200640000 | MITTAN 1 | 41.113095 | -104.376896 | INTERCONTINENTAL PETROLEUM | 9/10/1969 | DRY HOLE, P & A | V | 8,576 | 8,576 |
| 49021200750000 | UPRR-ROHER 1 | 41.112513 | -104.251372 | GROSS TODD | 5/21/1970 | DRY HOLE, P & A | V | 7,967 | 7,967 |
| 49021200760000 | BUTLER 1 | 41.109168 | -104.228575 | GROSS TODD | 9/12/1970 | DRY HOLE, P & A | V | 7,925 | 7,925 |
| 49021200940000 | LEO JESSEN 2-33 | 41.140242 | -104.097599 | TARGET OIL | 10/25/1972 | DRY HOLE, P & A | V | 7,406 | 7,412 |
| 49021200990000 | UPRC-RESOURCE CORP 1 | 41.119735 | -104.142473 | TARGET OIL | 1/31/1973 | DRY HOLE, P & A | V | 7,636 | 7,636 |
| 49021201000000 | HOBBS 1 | 41.181179 | -104.165608 | POLUMBUS CORP | 2/11/1973 | DRY HOLE, P & A | V | 7,590 | 7,646 |
| 49021201050000 | DOLAN 13-10 | 41.101812 | -104.195054 | DIAMONDBACK ENERGY | 8/8/1973 | DRY HOLE, P & A | V | 7,836 | 7,836 |
| 49021201330000 | LEO JESSEN 1-5 | 41.119693 | -104.113673 | FINA OIL & CHEMICAL CO | 8/23/1976 | DRY HOLE, P & A | V | 7,493 | 7,493 |
| 49021201440000 | CHAMPLIN 325 AMOCO A 1 | 41.058315 | -104.257346 | BP | 7/11/1976 | DRY HOLE, P & A | V | 7,990 | 7,990 |

| API Number | Well Name | Latitude (WGS84) | Longitude (WGS84) | Operator | Spud Date | Well Status | Drill Type | Total Vertical Depth | Measured Depth (TD) |
|---|---|---|---|---|---|---|---|---|---|
| 49021201490000 | CHAMPLIN 350 AMOCO-A 1 | 41.058978 | -104.463925 | BP | 9/12/1976 | DRY HOLE, P & A | V | 8,600 | 8,600 |
| 49021201500000 | CHAMPLIN 329 AMOCO A 1 | 41.017055 | -104.3909 | BP | - | DRY HOLE, P & A | V | 8,247 | 8,247 |
| 49021201580000 | JESSEN 22-5 | 41.122303 | -104.112476 | HAUG LAWRENCE | 1/11/1977 | OIL, P & A | V | 7,421 | 7,421 |
| 49021201640000 | UPRR-GARDNER BROS 1 | 41.069149 | -104.157084 | GROSS TODD | 2/16/1977 | DRY HOLE, P & A | V | 7,679 | 7,679 |
| 49021201650000 | CHAMPLIN 281 AMOCO-A 1 | 41.149172 | -104.347034 | BP | 2/20/1977 | DRY HOLE, P & A | V | 8,280 | 8,280 |
| 49021201840000 | STATE 12-31 | 41.051036 | -104.138821 | CORRIDA OIL INC | 8/16/1977 | OIL, P & A | V | 7,703 | 7,703 |
| 49021202000000 | GARDNER 13-9 | 41.105007 | -104.099277 | DUNCAN OIL | 6/20/1978 | DRY HOLE, P & A | V | 7,700 | 7,700 |
| 49021202110000 | FORNSTROM 1-21 | 41.170076 | -104.098848 | GENERAL AMERICAN OIL CO OF TEXAS | 5/5/1979 | DRY HOLE, P & A | V | 7,427 | 7,427 |
| 49021202120000 | CARPENTER 1 | 41.141374 | -104.127925 | GROSS TODD | 9/15/1979 | DRY HOLE, P & A | V | 7,532 | 7,532 |
| 49021202210000 | CHAMPLIN 460 B 1 | 41.061902 | -104.142846 | BP | 7/20/1980 | DRY HOLE, P & A | V | 7,973 | 7,973 |
| 49021202220000 | CHAMPLIN 325 AMOCO B 1 | 41.08399 | -104.2904 | DJ RESOURCES INC | 8/1/1980 | OIL, P & A | V | 8,408 | 8,408 |
| 49021202320000 | CHAMPLIN 460 AMOCO A 1 | 41.101751 | -104.171156 | BP | 1/21/1981 | DRY HOLE, P & A | V | 7,810 | 7,810 |
| 49021202390000 | MORRITZ BROTHERS 1-17 | 41.090762 | -104.104565 | ATLANTIC OIL COMPANY | 7/6/1981 | OIL, P & A | V | 7,650 | 7,650 |
| 49021202410000 | WINTER FARMS 1-8 | 41.105238 | -104.113796 | ATLANTIC OIL COMPANY | 7/17/1981 | OIL, P & A | V | 7,650 | 7,650 |
| 49021202420000 | ALLEN STATE 1-30 | 41.065481 | -104.12852 | ATLANTIC OIL COMPANY | 6/26/1981 | OIL, P & A | V | 7,650 | 7,650 |
| 49021202530000 | UPRR BUTLER 1-17 | 41.087433 | -104.219304 | PRIVATE OIL INDUSTRIES | 10/12/1981 | OIL, P & A | V | 7,924 | 7,924 |
| 49021202540000 | UPRR-PALM 1-21 | 41.07318 | -104.324348 | TRANSTEXAS ENERGY | 10/14/1981 | DRY HOLE, P & A | V | 9,424 | 9,424 |
| 49021202550000 | UPRR HRUSKA FEE 1-1 | 41.032344 | -104.144599 | TRANSTEXAS ENERGY | 10/27/1981 | DRY HOLE, P & A | V | 7,798 | 7,798 |
| 49021202570000 | UPRR-MCNALLY FEE 1-7 | 41.018415 | -104.369148 | TRANSTEXAS ENERGY | 12/16/1981 | DRY HOLE, P & A | V | 8,284 | 8,284 |
| 49021202580000 | UPRR-WYOBRASKA FEE 1-17 | 41.014237 | -104.120763 | TRANSTEXAS ENERGY | 11/19/1981 | DRY HOLE, P & A | V | 7,660 | 7,660 |
| 49021202610000 | WINTER FARMS 11-8 | 41.112336 | -104.118687 | TERRA ENERGY PARTNERS LLC | 2/24/1982 | DRY HOLE, P & A | V | 7,600 | 7,600 |
| 49021202670000 | BARKELL 1 | 41.181058 | -104.156068 | WORLDWIDE ENERGY CORP | - | COMPLETED | U | - | - |

| API Number | Well Name | Latitude (WGS84) | Longitude (WGS84) | Operator | Spud Date | Well Status | Drill Type | Total Vertical Depth | Measured Depth (TD) |
|---|---|---|---|---|---|---|---|---|---|
| 49021202720000 | GROSS-WILKINSON 11-9 | 41.191729 | -104.093613 | BRADEN OIL | 8/14/1982 | DRY HOLE, P & A | V | 7,368 | 7,368 |
| 49021202810000 | NORTH FORK 1 | 41.163434 | -104.289581 | PDC ENERGY | - | COMPLETED | U | - | - |
| 49021202820000 | NORTH HERFORD FEE 1 | 41.017783 | -104.277524 | PDC ENERGY | 12/31/1982 | DRY HOLE, P & A | V | 8,100 | 8,100 |
| 49021203350000 | FORNSTROM 1-20 | 41.162938 | -104.113183 | HRUBETZ OIL CO. | 3/8/1984 | DRY HOLE, P & A | V | 7,480 | 7,480 |
| 49021203670000 | BREEDEN 8-16 | 41.017956 | -104.449574 | COLE JACK A | 3/14/1985 | DRY HOLE, P & A | V | 7,879 | 7,879 |
| 49021203690000 | GRAHAM 14-11 | 41.008508 | -104.400771 | GARY-WILLIAMS PRODUCTION CO. | 3/22/1985 | DRY HOLE, P & A | V | 7,736 | 7,736 |
| 49021204470000 | M LAZY M 42-13 | 41.181478 | -104.255919 | NEWPORT EXPL | 3/31/1992 | DRY HOLE, P & A | V | 7,294 | 7,294 |
| 49021205450000 | WILHELM 2 | 41.148203 | -104.12782 | PAR PACIFIC HOLDINGS | 7/2/2004 | OIL, P & A | V | 7,656 | 7,656 |
| 49021205900000 | DUELLO 34-5 | 41.20225 | -104.10725 | BEAR OIL & GAS | 4/3/2009 | OIL, P & A | V | 7,525 | 7,700 |
| 49021206690000 | STATE 14-63-36-1H | 41.13122 | -104.37179 | ENCAP | 8/23/2010 | OIL, P & A | H | 7,450 | 12,695 |
| 49021207280000 | NOYER 24-10H | 41.01772 | -104.3055 | CCRP OPERATING INC | 12/13/2011 | OIL, ACTIVE | H | 8,065 | 11,635 |
| 49021207380000 | JOHNSON 44-12H | 41.01763 | -104.375809 | CCRP OPERATING INC | 9/19/2012 | OIL, ACTIVE | H | 7,382 | 11,992 |
| 49021207980000 | SMITH 44-6H | 41.03191 | -104.35287 | CCRP OPERATING INC | 6/6/2012 | OIL, ACTIVE | H | 7,410 | 11,700 |
| 49021208360000 | BREEDEN 2-17H | 41.01527 | -104.4567 | CCRP OPERATING INC | 10/21/2011 | OIL, ACTIVE | H | 7,686 | 11,804 |
| 49021208380000 | KONIG 2-11H | 41.03031 | -104.39906 | CCRP OPERATING INC | 10/10/2012 | OIL, P & A | H | 7,505 | 11,930 |
| 49021208880000 | GORDON 1-12H | 41.10107 | -104.37137 | GBK CORPORATION | 12/30/2011 | OIL, TA | H | 7,641 | 11,984 |
| 49021208890000 | SNEESBY 44-9H | 41.10089 | -104.31407 | GBK CORPORATION | 12/30/2011 | OIL, TA | H | 7,324 | 11,700 |
| 49021214870000 | CARPENTER 523-0428H | 41.04194 | -104.44449 | EOG RESOURCES | 6/29/2019 | OIL, ACTIVE | H | 7,733 | 18,002 |
| 49021216970000 | ARCOLA 102-3229H | 41.04435 | -104.45854 | EOG RESOURCES | 2/3/2018 | OIL, INACTIVE | H | 7,761 | - |
| 49021217480000 | CARPENTER 126-0408H | 41.04194 | -104.44431 | EOG RESOURCES | 7/29/2019 | OIL, ACTIVE | H | 7,651 | 17,034 |
| 49021217490000 | CARPENTER 127-0429H | 41.042089 | -104.444492 | EOG RESOURCES | 2/15/2019 | OIL, ACTIVE | H | 10,200 | 17,929 |
| 49021224410000 | RESOLUTION 13-63-14-23-6CH | 41.10249 | -104.39176 | OCCIDENTAL PETROLEUM | - | OIL, DRILLED | H | 11,631 | 11,770 |
| 49021252260000 | ROCK PICK 1 | 41.09971 | -104.38082 | OCCIDENTAL PETROLEUM | 10/8/2017 | STRATIGRAPHIC/CORE TEST, P & A | D | 7,731 | - |
| 49021295480000 | JUNIPER M-1 | 41.055968 | -104.271948 | TALLGRASS HIGH PLAINS CARBON STORAGE,LLC | 1/25/2023 | UNKNOWN, DUC | V | 9,800 | 9,800 |

| API Number | Well Name | Latitude (WGS84) | Longitude (WGS84) | Operator | Spud Date | Well Status | Drill Type | Total Vertical Depth | Measured Depth (TD) |
|---|---|---|---|---|---|---|---|---|---|
| 49021314340000 | CARPENTER 507-0529H | 41.042158 | -104.451953 | EOG RESOURCES | - | OIL, UNKNOWN | H | 7,753 | - |
| 49021600070000 | GROSS-WILLARD 1 | 41.166682 | -104.113113 | CHAMPION VENTURES INC | 11/24/1962 | DRY HOLE, P & A | V | 7,423 | 7,423 |
| 49021600080000 | C FORNSTROM 1 | 41.164754 | -104.110767 | TEXAS AMERICAN OIL CORP | 5/15/1931 | DRY HOLE, P & A | V | 7,440 | 7,440 |
| 49021600130000 | MORRITZ BROS 1-17 | 41.090762 | -104.104565 | ATLANTIC INTERNATIONAL | 7/6/1981 | UNKNOWN, P & A | V | - | - |
| 49021600140000 | ALLEN STATE 1-30 | 41.065481 | -104.12852 | ATLANTIC INTERNATIONAL | 6/25/1981 | UNKNOWN, P & A | V | - | - |
| 49021600150000 | WINTER FARMS 1-8 | 41.105238 | -104.113796 | ATLANTIC INTERNATIONAL | 7/16/1981 | UNKNOWN, P & A | V | - | - |

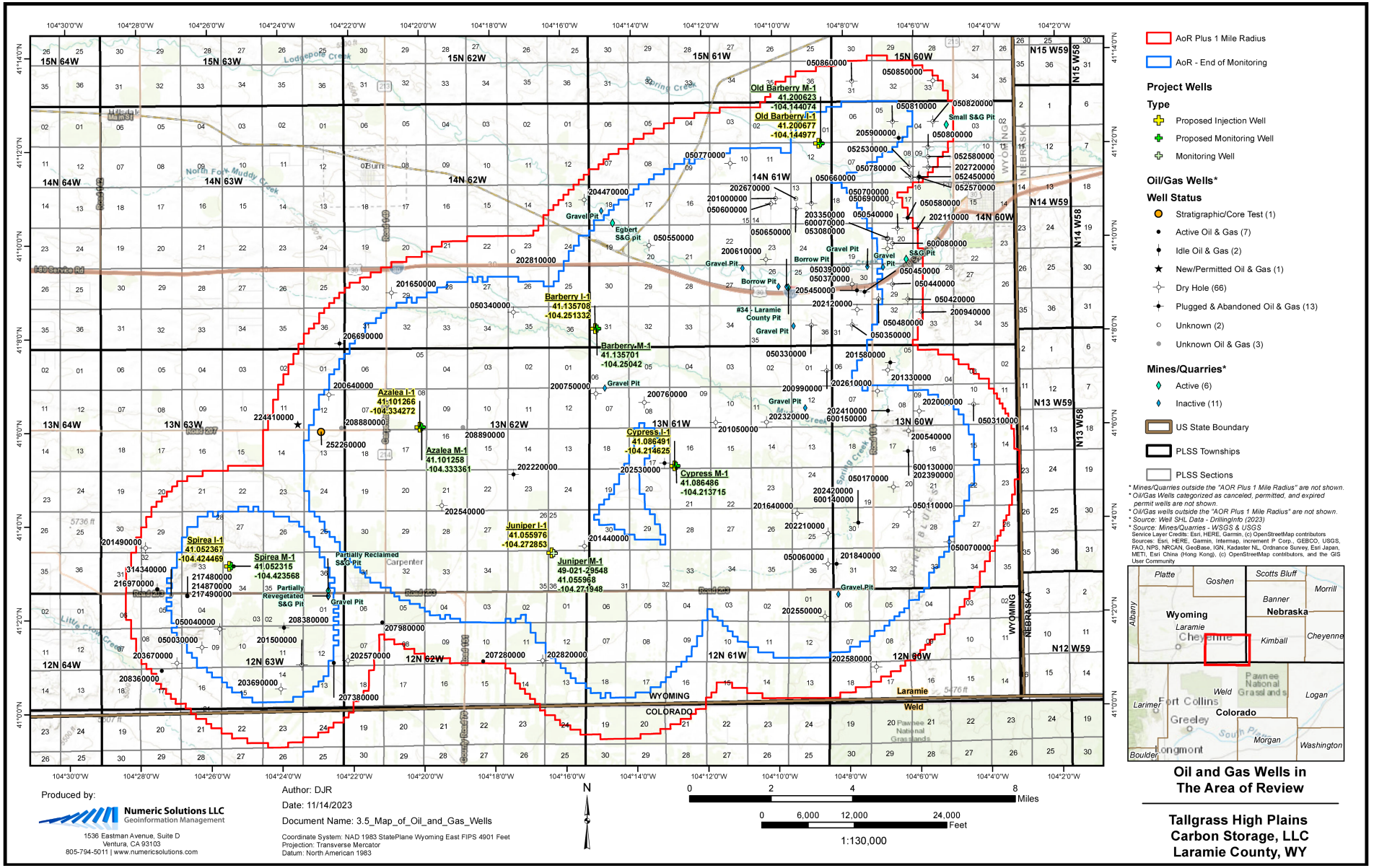



Figure B.36—Oil and gas wells in the area of review.

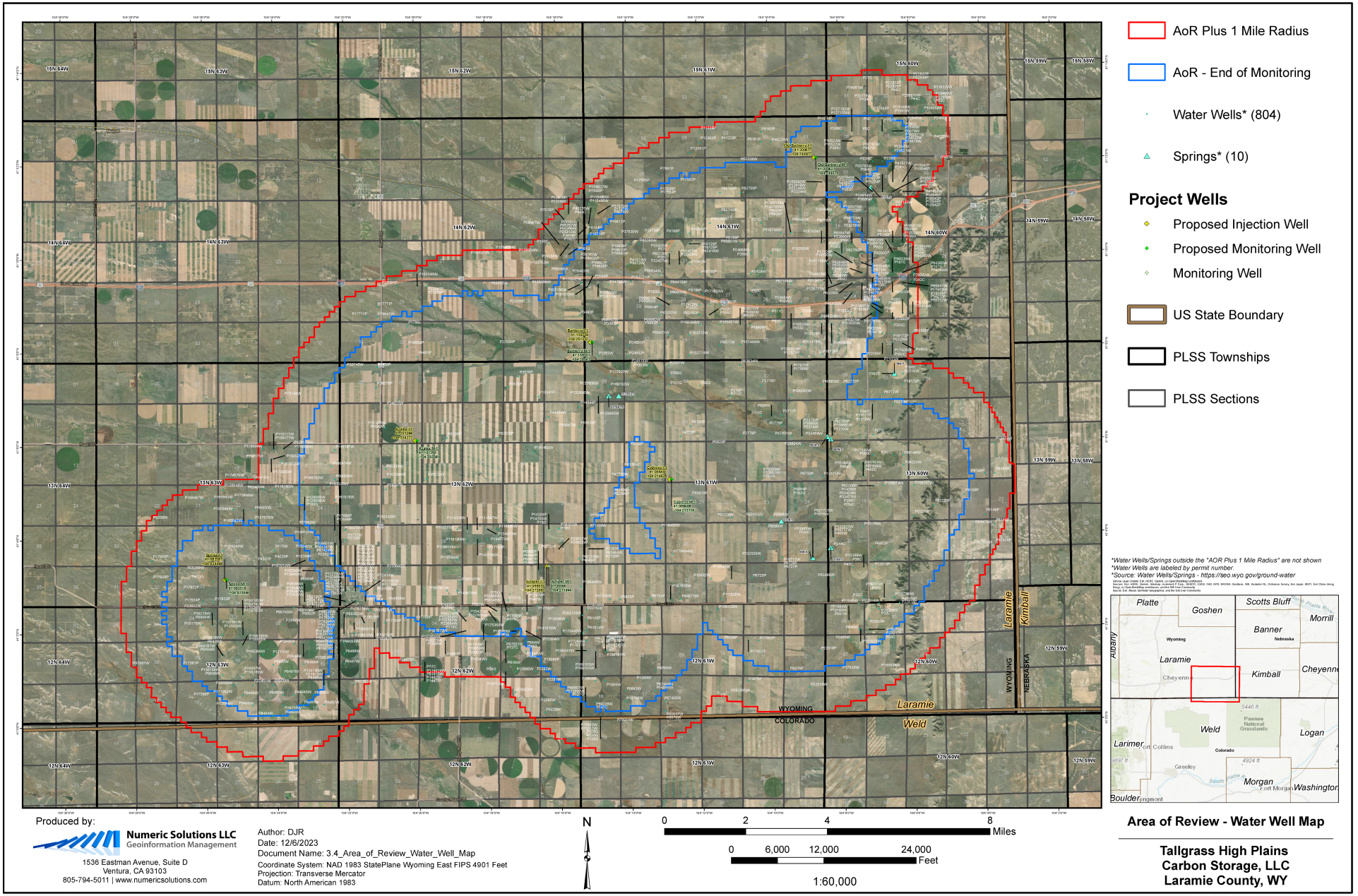



Figure B.37—Map of water wells within the area of review.

Table B.7—Water wells located in the area of review plus a one-mile buffer.

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P100.0C | FADJ | IRR_GW | WILHELM #1 | 80 |
| P10007.0W | FADJ | IRR_GW | WERNER #4 | 185 |
| P10008.0W | FADJ | IRR_GW | WERNER #5 | 178 |
| P100592.0W | COM | DOM_GW; STK | BARRY #1 | 280 |
| P101243.0W | COM | DOM_GW | SMITH #1 | 160 |
| P102571.0W | COM | DOM_GW | LOUISE #1 | 600 |
| P102854.0W | FADJ | IRR_GW | ENL BAUMAN #8 | 120 |
| P102855.0W | FADJ | IRR_GW | ENL SNYDER #1 WELL | 120 |
| P102856.0W | FADJ | IRR_GW | ENL DEMUTH #1 WELL | 92 |
| P102857.0W | FADJ | IRR_GW | ENL SNYDER #2 WELL | 100 |
| P102858.0W | INC | MIS | CARPENTER SCHOOL #1 | 500 |
| P103349.0W | COM | DOM_GW; STK | LEININGER #3 | 160 |
| P103753.0W | COM | STK | MINNICK RANCH #1 | 190 |
| P104058.0W | COM | DOM_GW; STK | S-1 | 100 |
| P104470.0W | COM | DOM_GW; STK | FRANZEN #1 | 200 |
| P104601.0W | COM | STK | ENL ELZIE #2 | 96 |
| P104678.0W | COM | DOM_GW | LODGE POLE VALLEY #1 | 330 |
| P105.0G | FADJ | IRR_GW | FORNSTROM BROS #1 | 100 |
| P1052.0W | FADJ | IRR_GW; STK | CHAMBERLAIN #1 | 93 |
| P10522.0W | FADJ | IRR_GW | ENL HENRY WISROTH #3 | 70 |
| P10523.0W | FADJ | IRR_GW | ENL HENRY WISROTH #4 | 50 |
| P10524.0W | FADJ | DOM_GW; MIS; STK | CELLAR #1 | 114 |
| P10526.0W | FADJ | IRR_GW | BROWN #3 | 120 |
| P1053.0W | FADJ | IRR_GW | CHAMBERLAIN #2 | 93 |
| P105366.0W | COM | DOM_GW | BURNETT WEST CARPENTER #1 | 160 |
| P10542.0P | COM | DOM_GW | WISROTH RANCH CO. #1 BY BARN | 50 |
| P10543.0P | COM | DOM_GW | WISROTH RANCH CO #2 MAIN HOUSE | 60 |
| P10544.0P | COM | DOM_GW | WISROTH RANCH CO. #3 HIRED MAN HOUSE | 60 |
| P10545.0P | COM | DOM_GW | WISROTH RANCH CO #4 | 80 |
| P10546.0P | COM | STK | WISROTH RANCH CO #5 BY CRICK | 50 |
| P10547.0P | COM | STK | WISROTH RANCH CO #6 | 100 |
| P10550.0P | COM | DOM_GW | WISROTH RANCH CO #9 NEW HOUSE | 70 |
| P10551.0P | COM | DOM_GW | WISROTH RANCH CO #10 HIRED HELP (DEEPENED) | 130 |
| P10552.0P | COM | DOM_GW | WISROTH RANCH CO. #11 HIRED HELP | 60 |
| P105582.0W | FADJ | MIS | ENL SW-12 | 120 |
| P105974.0W | COM | DOM_GW | RCA #1 | 170 |
| P106.0C | FADJ | IRR_GW | DAVIS #1 | 74 |
| P106.0G | FADJ | STK | CARL G FORNSTROM #3 | 100 |
| P1064.0W | FADJ | IRR_GW | BAUMAN #10 | 140 |
| P1065.0W | FADJ | IRR_GW | BAUMAN #11 | 120 |
| P107.0G | FADJ | STK | CARL G FORNSTROM #4 | 80 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P10717.0W | COM | DOM_GW; STK | MORSE #3 | 63 |
| P107198.0W | COM | DOM_GW; STK | ROY #1 | 225 |
| P107494.0W | COM | STK | FERGUSON RANCH #1 | 210 |
| P108113.0W | INC | DOM_GW; MIS; STK | DERSTINE #1 | 190 |
| P109007.0W | COM | DOM_GW; STK | DERSTINE #2 | 200 |
| P1091.0W | FADJ | IRR_GW | BYMER #1 | 96 |
| P110.0W | COM | STK | OLINE #1 | 175 |
| P110129.0W | COM | DOM_GW | PARSONS WELL | 500 |
| P110172.0W | COM | DOM_GW; STK | KEN MALM #2 | 100 |
| P110177.0W | COM | DOM_GW; STK | JENNY #1 | 200 |
| P110643.0W | COM | DOM_GW | JOHNSON 1 | 100 |
| P110848.0W | COM | DOM_GW; STK | Veal #1 | 200 |
| P111.0C | FADJ | IRR_GW | DOLAN #1 | 100 |
| P111.0G | FADJ | IRR_GW | PHILLIPS #4 | 105 |
| P111541.0W | FADJ | DOM_GW; MIS; STK | Burnett Thompson #1 | 200 |
| P111838.0W | COM | DOM_GW | S & K #1 | 340 |
| P112.0C | FADJ | IRR_GW | DOLAN #2 | 100 |
| P11224.0P | COM | STK | WISROTH #1 STOCK | 65 |
| P11225.0P | COM | STK | WISROTH #2 STOCK | 100 |
| P11226.0P | COM | STK | WISROTH #3 STOCK | 100 |
| P11227.0P | COM | DOM_GW | WISROTH #1 DOMESTIC (REL/DEEP) | 25 |
| P11228.0P | COM | DOM_GW | WISROTH #2 DOMESTIC | 80 |
| P11229.0P | COM | DOM_GW | WISROTH DOMESTIC #3 | 75 |
| P11230.0P | COM | STK | MC CARTY #1 | 100 |
| P11231.0P | COM | STK | BURNS #1 | 50 |
| P1127.0W | FADJ | IRR_GW | PONY EXPRESS #1 | 120 |
| P112792.0W | FADJ | MIS | CARPENTER DISTRICT #1 | 480 |
| P112793.0W | FADJ | MIS | ENL CARPENTER  SCHOOL #1 | 500 |
| P113537.0W | COM | DOM_GW | FILKINS #1 | 260 |
| P11407.0W | FADJ | IRR_GW; STK | MEIER #3 | 130 |
| P115490.0W | COM | DOM_GW | STEEGE #1 | 140 |
| P115495.0W | COM | DOM_GW | ENL SMITH #5 | 50 |
| P116180.0W | COM | DOM_GW; STK | LORETTA & LANNY SCONYERS #1 | 460 |
| P116190.0W | COM | DOM_GW; STK | TRUE #2 | 160 |
| P116571.0W | COM | DOM_GW; STK | YOUNG #1 | 500 |
| P116582.0W | COM | DOM_GW; STK | GROSS #1 | 116 |
| P116589.0W | COM | DOM_GW; STK | Tricia #1 | 480 |
| P116635.0W | COM | DOM_GW; STK | FOX #1 | 170 |
| P116694.0W | COM | DOM_GW; STK | WARNER #1 | 260 |
| P116743.0W | COM | DOM_GW; STK | TOM FORNSTROM #1 | 500 |
| P118326.0W | COM | DOM_GW; STK | BRITTNEY NOEL | 500 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P118652.0W | COM | STK | Jessen 1 | 120 |
| P12000.0W | INC | IRR_GW | BROWN ENTERPRISES SEC 24 #1 | 180 |
| P120606.0W | COM | DOM_GW; STK | Jack Hockersmith, JR. #1 | 120 |
| P12061.0P | COM | STK | FARINGTON #1 | 130 |
| P12062.0P | COM | STK | FARINGTON #2 | 60 |
| P12070.0P | COM | STK | BOMHOFF #13 | 100 |
| P121.0G | FADJ | IRR_GW | PLAMBECK #2 WELL | 80 |
| P12111.0W | FADJ | IRR_GW; STK | S E KEITH #1 | 158 |
| P121687.0W | COM | DOM_GW; STK | ZIEGLER #1 | 400 |
| P124102.0W | INC | IRR_GW | Martin No. 1 | 196 |
| P126065.0W | INC | IRR_GW | 1ST Enl Water Well #1 | 155 |
| P126066.0W | INC | IRR_GW | Soppe #1 | 106 |
| P126248.0W | COM | DOM_GW; STK | DISENSO #1 | 240 |
| P126548.0W | COM | DOM_GW; STK | RUNAWAY ROSE #1 | 300 |
| P126614.0W | COM | DOM_GW; STK | FIEDOR #1 | 490 |
| P126711.0W | COM | DOM_GW | Butler #1 | 620 |
| P127.0G | FADJ | IRR_GW | BAUMAN #3 | 152 |
| P127102.0W | INC | TST | TEST 1 | 125 |
| P127103.0W | INC | TST | TEST 2 | 125 |
| P128.0G | FADJ | IRR_GW | BAUMAN #4 | 130 |
| P129.0G | FADJ | IRR_GW | BAUMAN #5 (RURAL ELECTRIC #3) | 113 |
| P129596.0W | COM | DOM_GW; STK | SCHOENE #2 | 560 |
| P130.0G | FADJ | IRR_GW | BAUMAN #6 | 112 |
| P131.0G | FADJ | IRR_GW | LANG #1 WELL | 95 |
| P13121.0W | COM | DOM_GW; STK | KASER #1 | 185 |
| P1318.0W | FADJ | IRR_GW | CLIFFORD #1 | 80 |
| P132996.0W | COM | DOM_GW | COULSON # 1 | 560 |
| P133920.0W | COM | STK | WADDLE STOCK # 1 | 500 |
| P134.0C | FADJ | IRR_GW | WILLIAM MACY #1 | 108 |
| P134073.0W | COM | DOM_GW | LORI BERGMAN WATER WELL | 420 |
| P134074.0W | COM | DOM_GW | JOHN & HEIDI WATER WELL | 300 |
| P13419.0W | FADJ | STK | SW-12 | 120 |
| P13423.0W | COM | DOM_GW | KENNETH GARDNER #1 | 735 |
| P135665.0W | COM | DOM_GW; STK | STUART # 1 | 360 |
| P135746.0W | COM | DOM_GW; STK | GASPAR # 1 | 180 |
| P135748.0W | INC | IRR_GW | Enl. RADKE # 10 | 152 |
| P13592.0W | FADJ | IRR_GW | WERNER #6 | 230 |
| P13593.0W | FADJ | IRR_GW | WERNER #7 | 220 |
| P13594.0W | FADJ | IRR_GW | WERNER #8 | 270 |
| P13595.0W | FADJ | IRR_GW | WERNER #9 | 118 |
| P13596.0W | FADJ | IRR_GW | WERNER #10 | 140 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P136512.0W | COM | DOM_GW; STK | BARKELL # 2 | 300 |
| P137.0C | FADJ | IRR_GW | JENNINGS #1 | 114 |
| P137605.0W | COM | DOM_GW | PLOVER 1 | 280 |
| P1380.0W | FADJ | IRR_GW | BAUMAN #12 | 124 |
| P138903.0W | COM | DOM_GW; STK | BLAKEY # 1 | 130 |
| P138904.0W | COM | DOM_GW; STK | MINNICK RANCH # 7 | 170 |
| P139061.0W | COM | DOM_GW; STK | CASEY # 1 | 380 |
| P140780.0W | COM | DOM_GW; STK | O'DELL # 1 | 560 |
| P141810.0W | COM | DOM_GW; STK | CHAD FOGG 1 | 430 |
| P14203.0W | FADJ | IRR_GW | SMITH #1 | 103 |
| P14204.0P | COM | DOM_GW | SMITH #D-1 | 90 |
| P14210.0P | COM | DOM_GW | HARER #1 | 460 |
| P143154.0W | COM | DOM_GW; STK | SMOCK #1 | 460 |
| P1439.0W | FADJ | IRR_GW | MORITZ BROS #5 | 108 |
| P14475.0P | COM | DOM_GW; STK | MABEL #1 | 85 |
| P14476.0P | COM | STK | DEAN #2 | 85 |
| P14477.0P | COM | DOM_GW; STK | DEAN #1 | 70 |
| P147.0C | FADJ | IRR_GW | BAUMAN #2 | 157 |
| P14798.0W | COM | STK | GORDON #2 | 125 |
| P14844.0P | COM | DOM_GW; STK | GORDON NO. 1 | 80 |
| P149674.0W | COM | DOM_GW; STK | MILLER # 1 | 520 |
| P150.0C | FADJ | IRR_GW | MILLER #1 | 90 |
| P15018.0P | COM | DOM_GW; STK | JOHNSON #1 | 100 |
| P150604.0W | COM | MIS | ENL. BURNETT THOMPSON NO. 1 | 200 |
| P15168.0W | FADJ | IRR_GW | ENL STEPHENS #2 | 110 |
| P15169.0W | FADJ | IRR_GW | ENL YOUNG #20 | 110 |
| P15170.0W | FADJ | IRR_GW | ENL YOUNG #24 | 100 |
| P15175.0W | FADJ | MIS | WYOMING POTATOES INC. #1 | 130 |
| P15179.0W | INC | IRR_GW | GLASSBURN #2 | 198 |
| P152035.0W | COM | DOM_GW | WELL #1 | 330 |
| P152774.0W | COM | DOM_GW; STK | BUCHANAN 1 | 540 |
| P15341.0P | COM | DOM_GW; STK | G.C. BUTLER #1 | 150 |
| P1549.0W | FADJ | IRR_GW | SNYDER #1 | 120 |
| P15494.0W | FADJ | IRR_GW | ENL JAY BROWN #5 | 110 |
| P155620.0W | COM | STK | STOCK-WINDMILL #2 | 100 |
| P15564.0W | COM | STK | FOGG #1 | 100 |
| P155921.0W | COM | STK | OLD N.W. WELL NO. 5 | 80 |
| P1561.0W | FADJ | IRR_GW | MALM #3 | 120 |
| P156185.0W | COM | IRR_GW | ENL MARTIN NO. 1 | 196 |
| P156186.0W | INC | IRR_GW | ENL WERNER #1 | 165 |
| P156187.0W | COM | IRR_GW | ENL WERNER #2 | 165 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P156188.0W | COM | IRR_GW | ENL WERNER #3 | 290 |
| P156189.0W | COM | IRR_GW | ENL WERNER #4 | 185 |
| P156190.0W | COM | IRR_GW | ENL WERNER #5 | 178 |
| P156191.0W | INC | IRR_GW | ENL WERNER #6 | 230 |
| P156192.0W | INC | IRR_GW | ENL WERNER #11 | 235 |
| P156267.0W | COM | STK | HOCKERSMITH #3 | 470 |
| P15738.0P | COM | STK | FRITZ #1 | 100 |
| P15739.0P | COM | DOM_GW; STK | FRITZ #2 | 100 |
| P15740.0P | COM | STK | FRITZ #3 | 100 |
| P15764.0P | COM | DOM_GW | BENJAMIN #1 | 60 |
| P15765.0P | COM | DOM_GW | PENWELL #1 | 80 |
| P157875.0W | COM | DOM_GW; STK | CROW CREEK 1 | 280 |
| P159176.0W | COM | DOM_GW; STK | BAER #4 | 500 |
| P159177.0W | COM | DOM_GW; STK | RUTH MARIA #1 | 500 |
| P15932.0W | FADJ | IRR_GW | AVERS #1 | 220 |
| P15945.0W | FADJ | IRR_GW | LOYD #2 | 220 |
| P15946.0W | FADJ | IRR_GW | LOYD #3 | 88 |
| P15948.0W | FADJ | IRR_GW | AVER #2 | 150 |
| P15953.0W | COM | DOM_GW; STK | MCNALLY #1 | 402 |
| P159921.0W | COM | DOM_GW; STK | STEPHENS WELL | 61 |
| P160529.0W | COM | DOM_GW; STK | STROOT #1 | 540 |
| P161.0G | FADJ | IRR_GW | GEORGE KASER #1 | 72 |
| P161082.0W | COM | DOM_GW; STK | DERSTINE NO.1 | 480 |
| P16128.0P | COM | STK | BYMER #2 | 80 |
| P16129.0P | COM | DOM_GW | BYMER #3 | 85 |
| P16130.0P | COM | STK | BYMER #4 | 50 |
| P161347.0W | COM | DOM_GW; STK | ELZIE #3 | 480 |
| P161419.0W | COM | DOM_GW; STK | NORMAN HOUSE #1 | 440 |
| P161819.0W | COM | DOM_GW | NUSZ #2 | 520 |
| P162512.0W | COM | DOM_GW | NOACK #1 | 500 |
| P163144.0W | COM | STK | SMITH I | 320 |
| P163521.0W | COM | DOM_GW | T-3 | 460 |
| P16483.0W | COM | DOM_GW; STK | YOUNGLUND #1 | 110 |
| P16500.0W | COM | DOM_GW; STK | FEEDLOT #1 | 525 |
| P16510.0W | INC | IRR_GW | ENL. PHILLIPS #4 | 160 |
| P165534.0W | COM | DOM_GW; STK | GROVE #1 | 150 |
| P165563.0W | COM | DOM_GW; STK | HASSELL #1 | 300 |
| P165642.0W | COM | DOM_GW | FRITTON #1 | 203 |
| P165646.0W | COM | DOM_GW | ALBRIGHT #1 | 260 |
| P167012.0W | COM | DOM_GW; STK | SMITH #1 | 520 |
| P16713.0W | COM | DOM_GW | PETERS #2 | 120 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P1675.0W | FADJ | IRR_GW | GARDNER #4 | 94 |
| P167523.0W | COM | DOM_GW | ANZMAN WELL | 500 |
| P168101.0W | UNA | MIS | BURNETT DAIRY #2 (NE) | 570 |
| P168102.0W | UNA | MIS | BURNETT DAIRY #3 (SE) | 570 |
| P168103.0W | UNA | MIS | BURNETT DAIRY #4 (SW) | 570 |
| P168128.0W | COM | DOM_GW | BUTLER #1 | 410 |
| P168467.0W | COM | DOM_GW; STK | 1-26 | 300 |
| P169.0G | FADJ | IRR_GW | BIRT #1 | 87 |
| P169241.0W | UNA | MIS | EMPLOY #1 | 520 |
| P169396.0W | COM | STK | RAY #1 | 540 |
| P169782.0W | COM | DOM_GW | BUCHANAN #1 | 280 |
| P17034.0W | FADJ | IRR_GW | WERNER #11 | 235 |
| P171.0C | FADJ | IRR_GW | HUGHES #1 | 85 |
| P171920.0W | COM | DOM_GW; STK | BIRT #1 | 120 |
| P171963.0W | COM | STK | EAST PASTURE WELL #4 | 440 |
| P172.0C | FADJ | IRR_GW; STK | SOUTH WELL #1 | 110 |
| P17225.0P | COM | DOM_GW | ANDERSON LIVESTOCK #2-19-14-60 | 100 |
| P17226.0P | COM | DOM_GW | ANDERSON LIVESTOCK #2-19-14-60(NW-SE) | 95 |
| P173605.0W | COM | DOM_GW; STK | MORGAN #2 | 520 |
| P173806.0W | COM | DOM_GW; STK | TEEPEE ROAD | 340 |
| P17419.0W | FADJ | MIS | HARER #2 | 115 |
| P17428.0W | COM | DOM_GW; STK | POTATO WASHER #1 (DEEPENED) | 350 |
| P17429.0W | FADJ | IRR_GW | ENL FORNSTORM #1 | 90 |
| P17430.0W | FADJ | IRR_GW | ENL MORITZ #3 | 80 |
| P17431.0W | INC | IRR_GW | ENL JESSEN #4 | 110 |
| P174519.0W | INC | IRR_GW | ENLARGEMENT RAGLAND NO. 1 WELL | 145 |
| P174579.0W | COM | STK | BURNS #1 | 300 |
| P175276.0W | COM | DOM_GW; STK | RODEBAUGH #1 | 280 |
| P175368.0W | COM | DOM_GW; STK | HOUSE #1 | 520 |
| P175445.0W | COM | DOM_GW; STK | NEAL #1 | 460 |
| P17553.0P | COM | STK | PELTON #1 | 38 |
| P17554.0P | COM | STK | PELTON #2 | 110 |
| P17555.0P | COM | STK | PELTON #3 | 120 |
| P17556.0P | COM | DOM_GW; STK | PELTON #4 | 110 |
| P17561.0P | COM | STK | SOUTH BLUFFS WELL #3 | 85 |
| P17562.0P | COM | STK | BOX 3 RANCH - EAST PASTURE WELL #4 | 86 |
| P17580.0P | COM | DOM_GW; STK | HOUSE #1 | 90 |
| P176.0C | FADJ | IRR_GW | DEMUTH #1 | 92 |
| P176642.0W | COM | DOM_GW; STK | ANAYA 1 | 400 |
| P17688.0P | COM | DOM_GW; STK | SOPPE #3 | 67 |
| P17689.0P | COM | DOM_GW; STK | SOPPE #2 | 65 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P176927.0W | COM | MIS | ENL. RICHES #1 | 45 |
| P17695.0P | COM | DOM_GW; STK | SMITH #1 (DEEPEN) | 440 |
| P17702.0P | COM | DOM_GW; STK | RAY #1 | 100 |
| P17703.0P | COM | STK | RAY #2 | 100 |
| P17704.0P | COM | STK | RAY #3 | 100 |
| P17705.0P | COM | STK | RAY #4 | 100 |
| P17706.0P | COM | STK | RAY #5 | 100 |
| P17707.0P | COM | DOM_GW; STK | RAY #6 | 100 |
| P17711.0P | COM | DOM_GW | SUYEMATSU #1 | 140 |
| P17712.0P | COM | STK | SUYEMATSU #2 | 90 |
| P17869.0P | COM | DOM_GW; STK | FRIEDEN #1 | 300 |
| P17870.0P | COM | DOM_GW; STK | FRIEDEN #2 | 90 |
| P17871.0P | COM | DOM_GW; STK | JOHNSON #1 | 91 |
| P17877.0P | COM | DOM_GW; STK | THOMPSON #1 | 60 |
| P17878.0P | COM | STK | THOMPSON #2 | 100 |
| P17885.0P | COM | DOM_GW | KENNETH MACY #3 | 90 |
| P179.0G | FADJ | IRR_GW | BASTIAN #2 WELL | 124 |
| P17900.0P | COM | STK | K 2 #4 | 80 |
| P17901.0P | COM | DOM_GW | MIKESELL #1 | 160 |
| P17902.0P | COM | STK | MIKESELL #2 | 200 |
| P17921.0P | COM | DOM_GW | BUCK'S PRIDE #1 | 165 |
| P17922.0P | COM | STK | DWINELL #3P | 90 |
| P17923.0P | COM | STK | DWINELL #1P | 105 |
| P17924.0P | COM | DOM_GW; STK | DWINELL #2P (DEEPENED) | 165 |
| P17926.0P | COM | STK | DWINELL #5 | 105 |
| P179694.0W | COM | DOM_GW | GUSTAFSON 01 | 280 |
| P18.0G | FADJ | IRR_GW | VAUGHAN #1 | 103 |
| P180.0G | FADJ | IRR_GW | WATER WELL #1 | 155 |
| P180857.0W | COM | DOM_GW; STK | CROW CREEK STATION #1 | 500 |
| P181573.0W | COM | DOM_GW; STK | JEFF & KIM DOMESTIC WELL | 520 |
| P181759.0W | COM | DOM_GW; STK | VASKO NUMBER ONE | 500 |
| P182620.0W | COM | DOM_GW; STK | WILKINS #1 | 330 |
| P183121.0W | COM | DOM_GW | BOWMAN SEC 29 #1 | 160 |
| P183335.0W | COM | DOM_GW; STK | LIT'L BIT OF LOVE #1 | 200 |
| P183865.0W | COM | STK | BOWMAN JESSEN #1 | 120 |
| P18597.0P | COM | DOM_GW; STK | LEO SMITH #2 | 65 |
| P18598.0P | COM | STK | LEO SMITH #3 | 65 |
| P18599.0P | COM | DOM_GW; STK | LEO SMITH #1 | 240 |
| P186468.0W | COM | DOM_GW; STK | BOULTON #1 | 500 |
| P186474.0W | COM | DOM_GW | NIKO-1 | 440 |
| P187.0C | FADJ | IRR_GW | FORNSTROM #1 | 84 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P1870.0W | FADJ | IRR_GW | HERBERT CAMPBELL FARM 4 WELL #6 | 180 |
| P187808.0W | INC | STK; IRR_GW | SONNY #2 | 3511 |
| P189478.0W | COM | DOM_GW | GROSZ #1 | 420 |
| P19.0G | FADJ | IRR_GW | VAUGHAN #2 | 97 |
| P191.0G | FADJ | IRR_GW | ADELS #3 | 100 |
| P191187.0W | COM | DOM_GW; STK | DUNAWAY 4 | 300 |
| P191493.0W | COM | STK | TK FORNSTROM #1 | 500 |
| P191610.0W | INC | DOM_GW; MIS | ANAYA #1 | 580 |
| P19175.0P | COM | DOM_GW | CAMPBELL #4 DOMESTIC | 60 |
| P19176.0P | COM | DOM_GW; STK | CAMPBELL #5 DOMESTIC | 80 |
| P19177.0P | COM | DOM_GW; STK | CAMPBELL #6 DOMESTIC | 100 |
| P19178.0P | COM | DOM_GW; STK | CAMPBELL #1 DOMESTIC | 65 |
| P19179.0P | COM | DOM_GW; STK | CAMPBELL #2 DOMESTIC | 50 |
| P19180.0P | COM | DOM_GW; STK | CAMPBELL #3 DOMESTIC | 75 |
| P192.0C | COM | DOM_GW | EGBERT WATER STATION WELL | 36 |
| P19216.0P | COM | DOM_GW; STK | DALE #2 (DEEPENED) | 103 |
| P193107.0W | COM | DOM_GW; STK | CARPENTER #1 | 525 |
| P194.0G | FADJ | IRR_GW; STK | BROWN #4 WELL | 90 |
| P19542.0P | COM | DOM_GW | SASS #1 | 148 |
| P19606.0P | COM | DOM_GW | EDWARD #1 | 100 |
| P19607.0P | COM | DOM_GW; STK | SMITH #1 | 120 |
| P19608.0P | COM | DOM_GW; STK | SMITH #2 | 45 |
| P19609.0P | COM | STK | SMITH #3 | 50 |
| P19610.0P | COM | DOM_GW; STK | SMITH #4 | 60 |
| P19612.0P | COM | STK | SMITH #6 | 100 |
| P19659.0P | COM | DOM_GW; STK | KURTH #3 | 60 |
| P19798.0W | FADJ | IRR_GW | BAUMAN 14-A | 100 |
| P198739.0W | COM | DOM_GW | YEIK #1 | 500 |
| P199703.0W | COM | DOM_GW | WOLFE 1 | 420 |
| P2015.0W | FADJ | IRR_GW | THOMPSON #1 | 100 |
| P203143.0W | COM | STK | THOMPSON NO. 1 | 100 |
| P20433.0W | COM | DOM_GW; STK | JAMES #1 | 200 |
| P2065.0W | FADJ | IRR_GW | BOWMAN #1 | 114 |
| P20668.0P | COM | DOM_GW; STK | E. GLANTZ #2 DOMESTIC | 100 |
| P20777.0W | FADJ | IRR_GW | ENL GARDNER #3 | 85 |
| P20778.0W | FADJ | IRR_GW | ENL WILLIAM MACY #1 | 108 |
| P20782.0W | FADJ | IRR_GW | ENL WISROTH #5 | 70 |
| P20783.0W | FADJ | IRR_GW | ENL HENRY WISROTH #2 | 80 |
| P20784.0W | FADJ | IRR_GW | ENL HENRY WISROTH #1 | 60 |
| P20810.0W | COM | DOM_GW | ANDREWS #1 | 110 |
| P20811.0W | COM | DOM_GW | ANDREWS #2 | 160 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P21.0G | FADJ | IRR_GW | PROSSER #1 | 90 |
| P2103.0W | FADJ | IRR_GW | JESSEN #1 | 180 |
| P21474.0P | COM | DOM_GW; STK | FOGG #7 | 120 |
| P21813.0W | COM | DOM_GW; STK | CRANWELL #1 | 70 |
| P22084.0P | COM | DOM_GW | #1 (WILHELM REDY MIX) | 90 |
| P22085.0P | COM | STK | J. BASTIAN #3 | 100 |
| P22087.0P | COM | DOM_GW; STK | J. BASTIAN #1 | 120 |
| P22088.0P | COM | DOM_GW; STK | J. BASTIAN #2 | 145 |
| P22090.0P | COM | STK | J. BASTIAN #4 | 125 |
| P22091.0P | COM | DOM_GW | J. BASTIAN #5 | 150 |
| P2215.0W | FADJ | IRR_GW | HERBERT CAMPBELL FARM 7 WELL #3 | 110 |
| P2216.0W | FADJ | IRR_GW | CAMPBELL TRUST FARM 6 WELL #6 | 185 |
| P22451.0W | COM | MON | WEST CARPENTER MONITOR #1 | 110 |
| P22513.0P | COM | STK | BOWMAN #1 | 130 |
| P22514.0W | COM | DOM_GW; STK | GASPAR DOMESTIC & STOCK #4 | 117 |
| P22515.0P | COM | DOM_GW; STK | BOWMAN #3 | 130 |
| P22516.0P | COM | DOM_GW; STK | BOWMAN #4 | 130 |
| P22517.0P | COM | DOM_GW; STK | BOWMAN #5 | 130 |
| P22518.0P | COM | STK | BOWMAN #6 | 60 |
| P22519.0W | INC | STK | BOWMAN NO. 7 | 140 |
| P2280.0W | FADJ | IRR_GW | VAN #1 | 150 |
| P2281.0W | FADJ | IRR_GW | VAN #2 | 157 |
| P2282.0W | FADJ | IRR_GW | VAN #3 | 150 |
| P22832.0P | COM | STK | GARDEN WELL #1 | 180 |
| P22835.0P | COM | DOM_GW; STK | STOCK WELL #4 | 180 |
| P22836.0P | COM | STK | STOCK WELL #5 | 180 |
| P22837.0P | COM | STK | STOCK WELL #6 | 160 |
| P22878.0P | COM | DOM_GW; STK | PINE BLUFFS MALM #1 | 100 |
| P231.0W | FADJ | IRR_GW | KENNETH L FORNSTROM #4 | 100 |
| P23145.0W | FADJ | IRR_GW | ENL WILKINSON #6 | 80 |
| P23146.0W | FADJ | IRR_GW | ENL GROSS WILKINSON 12-1 | 105 |
| P23286.0P | COM | DOM_GW; STK | #4 NOYER | 110 |
| P23287.0P | COM | DOM_GW; STK | #3 NOYER | 80 |
| P2334.0W | FADJ | IRR_GW | GROSS-WILKINSON 12-1 | 120 |
| P23652.0W | INC | IRR_GW | ENL GLASSBURN #2 | 198 |
| P23660.0W | FADJ | IRR_GW | ENL YOUNG #9 | 110 |
| P23661.0W | FADJ | IRR_GW | ENL ADELS #3 | 100 |
| P23664.0W | FADJ | IRR_GW | SNYDER #2 | 100 |
| P2369.0W | FADJ | IRR_GW | ANDERSON LIVESTOCK #5 | 125 |
| P2374.0W | FADJ | IRR_GW | JESSEN #2 | 115 |
| P2375.0W | FADJ | IRR_GW | JESSEN #3 | 115 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P23790.0P | COM | DOM_GW | O.F. JEWELL #1 | 84 |
| P23791.0P | COM | DOM_GW | CEMETERY #1 | 83 |
| P238.0C | FADJ | IRR_GW | CARL WISROTH #1 | 130 |
| P239.0C | FADJ | IRR_GW | CARL WISROTH #2 | 80 |
| P24.0G | FADJ | IRR_GW | BOWERS #2 | 95 |
| P240.0C | FADJ | IRR_GW | CARL WISROTH #3 | 80 |
| P241.0C | FADJ | IRR_GW | HOME WELL #4 | 100 |
| P242.0C | FADJ | IRR_GW | N W WELL #5 | 130 |
| P2428.0W | FADJ | IRR_GW | PROSSER #3 | 92 |
| P243.0C | FADJ | IRR_GW | GARDNER #1 | 30 |
| P244.0C | FADJ | IRR_GW | GARDNER #2 | 96 |
| P24518.0W | FADJ | IRR_GW | ENL CHAMBERLAIN #2 | 93 |
| P24519.0W | FADJ | IRR_GW | ENL WISROTH #6 | 80 |
| P24520.0W | FADJ | IRR_GW | ENL WELL #10 | 90 |
| P24521.0W | FADJ | IRR_GW | ENL WISROTH #5A | 80 |
| P2460.0W | FADJ | IRR_GW | BOWMAN #2 | 125 |
| P24651.0P | COM | STK | STOCKWELL #1 | 112 |
| P24652.0P | COM | DOM_GW; STK | HOUSE WELL #1 | 136 |
| P24685.0W | FADJ | IRR_GW | ENL YOUNG #10 | 110 |
| P24686.0W | FADJ | IRR_GW | ENL JOHN PROSSER #1 | 100 |
| P24914.0W | COM | DOM_GW | HOUSE #1 | 90 |
| P25042.0W | COM | STK | 122 | 100 |
| P25042.0W | COM | STK | - | 100 |
| P252.0C | FADJ | IRR_GW | FORNSTROM #1 | 90 |
| P25269.0W | FADJ | IRR_GW | GLASSBURN #3 | 336 |
| P2544.0W | FADJ | IRR_GW | WISROTH #5A | 80 |
| P2545.0W | FADJ | IRR_GW | WISROTH #7 | 80 |
| P2546.0W | FADJ | IRR_GW | WISROTH #6 | 80 |
| P25484.0W | COM | DOM_GW; STK | WILLOUGHBY #1 | 468 |
| P255.0C | FADJ | IRR_GW | BROWN BROS. #1 | 120 |
| P256.0C | FADJ | IRR_GW | BROWN BROS #2 | 100 |
| P258.0C | INC | IRR_GW | MORITZ #1 | 110 |
| P259.0C | FADJ | IRR_GW | MORITZ #2 | 110 |
| P25921.0P | INC | DOM_GW; STK | ELZIE #1 | 75 |
| P2597.0W | COM | DOM_GW | WOOD #1 | 188 |
| P26.0G | FADJ | IRR_GW | HERBERT CAMPBELL FARM 3 WELL #3 | 87 |
| P260.0C | FADJ | IRR_GW | MORITZ #3 | 80 |
| P26007.0P | COM | DOM_GW | DORAN #1 | 70 |
| P26075.0P | COM | DOM_GW | BLACK #1 | 75 |
| P261.0C | FADJ | IRR_GW | MORITZ #4 | 130 |
| P26395.0W | FADJ | IRR_GW | ENL LOYD #3 | 88 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P26396.0W | FADJ | IRR_GW | ENL LOYD #2 | 220 |
| P26397.0W | FADJ | IRR_GW | ENL LOYD #3 | 88 |
| P26783.0W | COM | DOM_GW; STK | HOUSE | 140 |
| P27.0C | FADJ | IRR_GW | C S MACY #1 | 96 |
| P27.0G | FADJ | IRR_GW | HERBERT CAMPBELL FARM 4 WELL #4 | 100 |
| P27736.0W | COM | DOM_GW; STK | TRUE #31 | 135 |
| P2776.0P | COM | DOM_GW; STK | DOLAN I. | 25 |
| P2777.0P | COM | STK | DOLAN 2 | 25 |
| P2778.0P | COM | STK | BOZORTH #1 | 465 |
| P2779.0P | COM | DOM_GW; STK | JEWELL #1 | 120 |
| P2780.0P | COM | DOM_GW; STK | RAZOR 1. | 42 |
| P27901.0P | COM | DOM_GW | VOSLER #1 | 65 |
| P28022.0W | COM | DOM_GW; STK | POELMA #1 | 126 |
| P28272.0W | FADJ | IRR_GW | ENL JAY BROWN #5 | 110 |
| P28355.0W | FADJ | IRR_GW | ENL KENNETH L FORNSTROM #4 | 120 |
| P2847.0W | FADJ | IRR_GW | PETERS #1 (DEEPENDED) | 170 |
| P2848.0W | FADJ | IRR_GW | PETERS #2 | 170 |
| P28483.0W | COM | DOM_GW; STK | SMITH #7 | 95 |
| P2849.0W | FADJ | IRR_GW | PETERS #3 | 170 |
| P28750.0P | COM | STK | PELTON #5 | 60 |
| P28804.0W | COM | STK | DRIETH #1 | 80 |
| P28903.0P | COM | DOM_GW; STK | BURBACH #4 | 77 |
| P28967.0W | FADJ | IRR_GW | MINNICK RANCH #1 | 110 |
| P29161.0P | COM | DOM_GW | SCHOENE #2 | 50 |
| P29628.0W | FADJ | MIS | FIRE DISTRICT #4 | 130 |
| P29632.0W | FADJ | IRR_GW | ENL S LANG #1 | 103 |
| P29633.0W | COM | STK | ANNABELLE #1 | 95 |
| P29689.0W | COM | DOM_GW; STK | LISA #1 | 100 |
| P29709.0W | COM | STK | RUDOLPH #1 | 200 |
| P29884.0W | FADJ | IRR_GW | ENL FORNSTROM BROS #1 | 100 |
| P29954.0W | FADJ | IRR_GW | ENL CARL FORNSTROM #1 | 83 |
| P29980.0W | FADJ | IRR_GW; STK | ENL DONALD #1 | 85 |
| P29981.0W | FADJ | IRR_GW; STK | ENL DONALD #2 | 80 |
| P304.0C | FADJ | IRR_GW | Carl Fornstrom No. 1 Well | 155 |
| P30415.0W | COM | DOM_GW; STK | LEO SMITH #4 | 140 |
| P305.0C | FADJ | IRR_GW | CARL FORNSTROM EAST #2 | 83 |
| P30723.0W | COM | DOM_GW; STK | CHARLES #1 | 460 |
| P30745.0W | COM | STK | STOCKWELL #1 | 95 |
| P31328.0W | FADJ | IRR_GW | MURDOCH #2-A | 140 |
| P314.0W | FADJ | IND_GW | SANDERS #2 | 104 |
| P31621.0W | COM | DOM_GW | WITTROCK #1 | 110 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P31761.0W | COM | DOM_GW; STK | LYONS #1 | 130 |
| P32.0C | FADJ | IRR_GW | YOUNG #21 | 85 |
| P32287.0W | COM | DOM_GW | SOPPE #1 | 126 |
| P32592.0W | COM | DOM_GW | ARNOLD #2 | 136 |
| P33.0C | FADJ | IRR_GW | YOUNG #22 | 100 |
| P33423.0W | FADJ | IRR_GW | ENL MORITZ BROS #5 | 108 |
| P33424.0W | FADJ | IRR_GW | ENL MORITZ #2 | 110 |
| P33427.0W | FADJ | IRR_GW | ENL MEIER #1 | 90 |
| P33428.0W | FADJ | IRR_GW | ENL MEIER #2 | 100 |
| P33429.0W | FADJ | IRR_GW | ENL MEIER #3 | 130 |
| P338.0G | FADJ | IRR_GW | BAUMAN #8 | 120 |
| P33888.0W | FADJ | IRR_GW | ENL WHITED | 109 |
| P34.0C | FADJ | IRR_GW | YOUNG #23 | 130 |
| P343.0C | FADJ | IRR_GW | HERBERT CAMPBELL FARM 2 WELL #1 | 100 |
| P344.0C | FADJ | IRR_GW | HERBERT CAMPBELL FARM 3 WELL #1 (DEEPENED) | 160 |
| P34426.0W | COM | DOM_GW; STK | FORNSTROM STOCK #2 | 80 |
| P34454.0W | COM | DOM_GW; STK | JESSEN #5 | 130 |
| P34606.0W | FADJ | IND_GW | FOXHILLS OBSERVATION WELL #1 | 910 |
| P34622.0W | COM | DOM_GW; STK | HOUSE WELL #1 | 135 |
| P347.0C | FADJ | IRR_GW | HERBERT CAMPBELL FARM 4 WELL #1 (DEEPENED) | 250 |
| P34765.0W | COM | DOM_GW | WARREN #1 | 145 |
| P34887.0W | COM | DOM_GW; STK | SCHWARTZ #3 | 465 |
| P3492.0P | COM | DOM_GW; STK | PALMER #1 | 127 |
| P3493.0P | COM | STK | PALMER #2 | 70 |
| P35.0C | FADJ | IRR_GW | MEIER #1 | 90 |
| P35014.0W | COM | DOM_GW | HAMMOND #1 | 145 |
| P352.0C | FADJ | IRR_GW | HERBERT CAMPBELL FARM 6 WELL #1 | 150 |
| P352.0G | INC | IRR_GW | POWELL #1 | 150 |
| P35312.0W | COM | DOM_GW | JIMENEZ #1 | 100 |
| P35421.0W | FADJ | IRR_GW | ENL BAUMAN #8 | 120 |
| P355.0C | FADJ | IRR_GW | HERBERT CAMPBELL FARM 6 WELL #4 | 80 |
| P35531.0W | COM | DOM_GW; STK | LEININGER #1 | 60 |
| P35532.0W | COM | STK | LEININGER #2 | 60 |
| P356.0C | FADJ | IRR_GW | HERBERT CAMPBELL FARM SEVEN (7) WELL NO. ONE (1) | 120 |
| P356.0G | FADJ | IRR_GW | PLAMBECK #3 | 93 |
| P357.0C | FADJ | IRR_GW | HERBERT CAMPBELL FARM 7 WELL #2 | 90 |
| P35737.0W | COM | DOM_GW | MARICK #1 | 150 |
| P3575.0P | COM | STK | BUTLER #1 | 85 |
| P3576.0P | COM | STK | BUTLER #2 | 115 |
| P359.0C | FADJ | IRR_GW | JOHN PROSSER #1 | 100 |
| P3595.0W | FADJ | IRR_GW; STK | JESSEN #4 | 120 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P36.0G | FADJ | IRR_GW | SMITH #1 | 163 |
| P360.0C | FADJ | IRR_GW | BOWERS #1 | 100 |
| P36015.0W | COM | DOM_GW | RUSSELL #1 | 134 |
| P361.0C | FADJ | IRR_GW | PHILLIPS #2 | 120 |
| P3619.0P | COM | DOM_GW; STK | JOHNSON #1 | 100 |
| P36218.0W | COM | STK | GLASSBURN STOCKWELL #2 | 83 |
| P36223.0W | COM | STK | MORITZ BROS. STOCK WELL #5 | 200 |
| P36288.0W | COM | DOM_GW | MEDINA #1 | 100 |
| P363.0C | FADJ | IRR_GW | HENRY WISROTH #1 | 60 |
| P364.0C | FADJ | IRR_GW | HENRY WISROTH #2 | 80 |
| P365.0C | FADJ | IRR_GW | HENRY WISROTH #3 | 120 |
| P366.0C | FADJ | IRR_GW | HENRY WISROTH #4 | 100 |
| P3678.0P | COM | DOM_GW; STK | ANDERSON #3 | 200 |
| P37.0C | FADJ | IRR_GW | MEIER #2 | 100 |
| P3729.0P | COM | DOM_GW; STK | ARP #1 | 68 |
| P375.0C | FADJ | IRR_GW | PHILLIPS #1 | 104 |
| P37570.0W | FADJ | IRR_GW | ENL PONY EXPRESS #1 | 120 |
| P3777.0W | COM | DOM_GW; STK | ARP #2 | 101 |
| P37829.0W | COM | MON | LARAMIE COUNTY OBSERVATION #1 | 120 |
| P37830.0W | COM | MON | LARAMIE COUNTY OBSERVATION #2 | 90 |
| P3806.0W | FADJ | IRR_GW | IVA'S FARM #2 | 145 |
| P39.0C | FADJ | IRR_GW | YOUNG #20 | 110 |
| P39070.0W | COM | DOM_GW; STK | KEENER #1 | 82 |
| P39551.0W | FADJ | DOM_GW; MIS; STK | ENL CARL G FORNSTROM #3 | 100 |
| P4.0G | FADJ | IRR_GW | NORTH #2 | 80 |
| P40.0C | FADJ | IRR_GW | YOUNG #24 | 100 |
| P40456.0W | FADJ | MIS | AIRPORT #1 | 475 |
| P406.0W | FADJ | IRR_GW | GARDNER #3 | 85 |
| P40883.0W | COM | DOM_GW; STK | JESSEN #6 | 135 |
| P41.0C | FADJ | IRR_GW | YOUNG #25 | 130 |
| P41409.0W | COM | DOM_GW; STK | DOMESTIC HOME WELL #1 | 130 |
| P41819.0W | FADJ | IRR_GW | ENL SCHINZELL #1 | 100 |
| P41821.0W | FADJ | IRR_GW | ENL HOME WELL #4 | 100 |
| P41939.0W | COM | DOM_GW | SWANSON #1 | 137 |
| P42293.0W | COM | DOM_GW | BUTLER #1 | 150 |
| P4230.0P | COM | DOM_GW; STK | OLINE #2 | 60 |
| P42309.0W | COM | DOM_GW | ANNABEL #1 | 128 |
| P4231.0P | COM | DOM_GW; STK | OLINE #3 | 60 |
| P42419.0W | COM | DOM_GW | BYMER #5 | 130 |
| P4327.0W | FADJ | IRR_GW | CAMPBELL FARM 3B | 110 |
| P43332.0W | COM | DOM_GW; STK | STEWART #1 | 110 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P44494.0W | COM | DOM_GW; STK | MIKESELL #3 | 176 |
| P4459.0P | COM | DOM_GW; STK | BLACK #1 | 30 |
| P4461.0P | COM | STK | BLACK #3 | 30 |
| P44792.0W | COM | DOM_GW | SANDERS DOMESTIC #1 | 515 |
| P44945.0W | COM | STK | RUDOLPH FARMS #18 | 233 |
| P45.0C | COM | STK | YOUNG #6 | 110 |
| P45274.0W | FADJ | IRR_GW | ENL DEMUTH # 1 | 92 |
| P45275.0W | FADJ | IRR_GW | ENL SNYDER #1 | 120 |
| P45276.0W | FADJ | IRR_GW | ENL DALE | 85 |
| P4570.0W | FADJ | IRR_GW | WISROTH RANCH CO #8 | 130 |
| P460.0G | FADJ | IRR_GW | HERBERT CAMPBELL FARM SIX (6) NO. FIVE (5) | 90 |
| P464.0C | FADJ | IRR_GW | ADELS #2 | 80 |
| P465.0C | FADJ | IRR_GW | ADELS #1 | 100 |
| P473.0G | FADJ | IRR_GW | OSBORN #1 | 336 |
| P47336.0W | COM | DOM_GW | TIBBITS #1 | 133 |
| P48238.0W | COM | STK | WISROTH #6 | 86 |
| P4848.0P | COM | DOM_GW; STK | PEERY #1 | 123 |
| P4849.0P | COM | STK | PEERY #2 | 82 |
| P4850.0P | COM | DOM_GW; STK | PEERY #3 | 68 |
| P4851.0P | COM | STK | PEERY #4 | 68 |
| P49.0C | FADJ | IRR_GW | YOUNG #9 | 110 |
| P492.0W | FADJ | IRR_GW | WISROTH #5 | 50 |
| P493.0C | FADJ | IRR_GW | DALE | 85 |
| P5.0C | FADJ | IRR_GW | WILKINSON #4 | 115 |
| P50.0C | FADJ | IRR_GW | YOUNG #10 | 110 |
| P50000.0W | COM | DOM_GW; STK | NUSZ #1 | 134 |
| P50068.0W | COM | STK | SCHOENE #1 | 125 |
| P50195.0W | COM | DOM_GW | E JUNE MORSE #1 | 118 |
| P50343.0W | COM | STK | BURBACH #2 | 100 |
| P50420.0W | COM | DOM_GW; STK | TALKINGTON #1 | 151 |
| P50814.0W | COM | DOM_GW; STK | THOMPSON #2 | 134 |
| P5120.0W | FADJ | IRR_GW | HERBERT COMPBELL TRUST FARM 6 #3 A | 140 |
| P5147.0W | FADJ | IRR_GW | BROWN #1 | 190 |
| P5161.0P | COM | STK | WISROTH #3 | 100 |
| P5162.0P | COM | STK | WISROTH #4 | 500 |
| P5208.0W | FADJ | IRR_GW | K2 WELL #1 | 250 |
| P53.0C | FADJ | IRR_GW; STK | DAVID BROWN #1 | 100 |
| P53108.0W | COM | DOM_GW | HONSTEIN #1 | 125 |
| P55421.0W | COM | DOM_GW; STK | DALE WELL #3 | 625 |
| P5590.0P | COM | DOM_GW | NULL | 190 |
| P56007.0W | COM | STK | VETTER #1 | 133 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P5602.0P | COM | DOM_GW; STK | CUSHING #1 | 81 |
| P56119.0W | COM | DOM_GW; STK | ENL CUSHING #1 | 81 |
| P56891.0W | COM | DOM_GW | JOHN #1 | 75 |
| P57382.0W | COM | DOM_GW | PACE #9 | 170 |
| P58149.0W | COM | DOM_GW; STK | HANEY #1 | 120 |
| P5840.0W | FADJ | IRR_GW | MURDOCH #2 | 160 |
| P59.0G | FADJ | IRR_GW | JENNINGS #2 WATER WELL | 110 |
| P59226.0W | FADJ | IRR_GW | ENL BAUMAN #2 | 157 |
| P5924.0P | COM | DOM_GW | THELEN #3D | 100 |
| P5925.0P | COM | DOM_GW | THELEN #2D | 100 |
| P59328.0W | FADJ | DOM_GW; MIS | METHODIST CHURCH #1 | 140 |
| P59396.0W | COM | DOM_GW; STK | WISECUP #1 | 98 |
| P59711.0W | COM | DOM_GW | POELMA #1 | 151 |
| P59712.0W | COM | DOM_GW | KNUPPEL #1 | 160 |
| P6.0C | FADJ | IRR_GW | WILKINSON #5 | 100 |
| P6004.0W | COM | DOM_GW; STK | BAUMAN RANCH STOCK #1 | 83 |
| P61301.0W | COM | DOM_GW | POELMA #1 | 120 |
| P616.0W | FADJ | IRR_GW | JENNINGS #3 | 107 |
| P61915.0W | COM | DOM_GW; STK | FERGY #1 | 152 |
| P62.0G | FADJ | IRR_GW | K FORNSTROM #2 | 85 |
| P6226.0W | COM | STK | VAN #4 WELL | 117 |
| P62328.0W | COM | STK | WISROTH SECTION 10 | 100 |
| P62484.0W | COM | DOM_GW | ENL LENNA #1 | 185 |
| P63.0C | FADJ | IRR_GW | DONALD #1 | 85 |
| P6339.0W | FADJ | IND_GW; IRR_GW | SANDERS #3 | 120 |
| P63488.0W | COM | DOM_GW | TRUE #1 | 120 |
| P63634.0W | COM | DOM_GW; STK | CAMPBELL #1 | 110 |
| P64.0C | FADJ | IRR_GW | DONALD #2 | 80 |
| P64636.0W | COM | DOM_GW | ARNOLD #2 | 150 |
| P6478.0W | FADJ | IRR_GW | WERNER #1 | 165 |
| P64908.0W | COM | DOM_GW; STK | KINNISON NO. 1 | 90 |
| P6494.0W | COM | STK | NELSON #1 | 52 |
| P65474.0W | COM | DOM_GW; STK | SPENCE #1 | 140 |
| P65718.0W | COM | DOM_GW; STK | ENL NORMAN #1 | 180 |
| P6589.0W | COM | IRR_GW | MCGUIRE NO. 1 | 130 |
| P65941.0W | COM | DOM_GW | HARER #3 | 468 |
| P661.0W | FADJ | IRR_GW | FORD WELL #1 | 103 |
| P664.0W | FADJ | IRR_GW | YOUNGLUND #1 | 133 |
| P66531.0W | COM | DOM_GW | MALLORY #1 | 85 |
| P6693.0P | COM | DOM_GW; STK | CULEK #1 | 100 |
| P6694.0P | COM | STK | CULEK #2 | 125 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P6712.0W | COM | STK | JESSEN #5 | 85 |
| P6727.0P | COM | DOM_GW; STK | MORSE #1 | 52 |
| P6728.0P | COM | DOM_GW; STK | MORSE #2 | 30 |
| P6729.0P | COM | DOM_GW; STK | MORSE #3 | 60 |
| P6730.0P | COM | STK | MORSE #4 | 25 |
| P6731.0P | COM | DOM_GW; STK | MORSE #5 | 100 |
| P67404.0W | COM | DOM_GW; STK | BRETT BAUMAN #1 | 80 |
| P67405.0W | COM | DOM_GW; STK | BRUCE BAUMAN #1 | 60 |
| P67424.0W | COM | STK | ELZIE #2 | 85 |
| P6808.0P | COM | STK | BARKELL #2 | 55 |
| P6809.0P | COM | DOM_GW | BARKELL #3 | 100 |
| P68403.0W | INC | MIS | MYERS #1 | 145 |
| P6843.0W | FADJ | IRR_GW | BAUMAN RANCH #15 | 139 |
| P686.0W | FADJ | IRR_GW | DOLAN #3 | 80 |
| P6884.0W | FADJ | IRR_GW | WERNER #2 | 165 |
| P693.0G | FADJ | IRR_GW | JAY BROWN #5 | 110 |
| P69541.0W | COM | DOM_GW; STK | BARKELL #1 | 500 |
| P6963.0P | COM | DOM_GW; STK | NORMAN #1 (DEEPENED) | 180 |
| P6964.0P | COM | STK | LINDA #1 | 85 |
| P6965.0P | COM | DOM_GW; STK | EDITH #1 | 147 |
| P6966.0P | COM | STK | RONALD #1 | 90 |
| P6967.0P | COM | DOM_GW; STK | CYNTHIA #1 | 90 |
| P6968.0P | COM | STK | FRANKLIN #1 | 89 |
| P69892.0W | COM | DOM_GW; STK | MANLEY #1 | 640 |
| P7.0C | FADJ | IRR_GW | WILKINSON #6 | 80 |
| P70163.0W | FADJ | IRR_GW | ENL ADELS #1 | 100 |
| P70164.0W | FADJ | IRR_GW | ENL ADELS #2 | 80 |
| P7106.0P | COM | DOM_GW; STK | JAMESON #1 | 80 |
| P7107.0P | COM | DOM_GW | LENNA #1 (DEEPENED) | 185 |
| P7108.0P | COM | DOM_GW; STK | CLAUDE #1 | 80 |
| P71139.0W | COM | DOM_GW; STK | AVERS #1 | 340 |
| P71584.0W | COM | STK | ROTE IV | 30 |
| P71585.0W | COM | DOM_GW; STK | ROTE V | 95 |
| P7210.0W | COM | DOM_GW; STK | JESSEN #6 | 80 |
| P72414.0W | COM | DOM_GW; STK | KAILEY #1 | 140 |
| P72431.0W | COM | STK | ENL LOYD #3 | 88 |
| P73145.0W | COM | DOM_GW; STK | MURDOCH #3 | 140 |
| P73893.0W | FADJ | IRR_GW; STK | ENL GARDNER #1 | 30 |
| P74061.0W | FADJ | MIS | PHEASANT #1 | 130 |
| P74106.0W | COM | STK | ENL MALM #3 | 120 |
| P75.0G | FADJ | IRR_GW | WHITED | 109 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P75043.0W | COM | DOM_GW | LEMBITZ #1 | 150 |
| P752.0G | FADJ | IRR_GW | GROSS-WILKINSON #1 | 115 |
| P75229.0W | COM | DOM_GW | LEE #1 | 90 |
| P75393.0W | COM | DOM_GW | MARICK #1 | 160 |
| P7578.0P | COM | DOM_GW | JOHNSON #2 | 39 |
| P76069.0W | FADJ | IRR_GW | ENL YOUNG #22 | 100 |
| P76070.0W | FADJ | IRR_GW | ENL YOUNG #23 | 130 |
| P76071.0W | FADJ | IRR_GW | ENL YOUNG #25 | 130 |
| P76082.0W | COM | DOM_GW; STK | DALE BOWMAN #4 | 94 |
| P76101.0W | FADJ | IRR_GW | ENL VAUGHAN #2 | 97 |
| P76176.0W | COM | STK | SECTION 5 #2 | 280 |
| P76414.0W | COM | STK | HOCKERSMITH STOCK WELL #1 | 120 |
| P76608.0W | COM | DOM_GW | POELMA #1 | 150 |
| P76717.0W | COM | DOM_GW | RHOADS #1 | 125 |
| P76934.0W | COM | STK | STOCK WELL 3 | 100 |
| P77.0C | FADJ | IRR_GW | RAGLAND #1 | 145 |
| P77264.0W | COM | DOM_GW; STK | KINKADE #1 | 160 |
| P77963.0W | COM | DOM_GW; STK | JOE NOYER #2 | 130 |
| P78843.0W | COM | DOM_GW; STK | DALE BOWMAN #5 | 83 |
| P7896.0P | COM | STK | RICHES #1 | 110 |
| P7897.0P | COM | STK | STANSBURY #1 | 260 |
| P79.0C | FADJ | IRR_GW | BROWN #1 | 100 |
| P79238.0W | FADJ | IRR_GW | ENL THOMPSON #1 | 100 |
| P79310.0W | FADJ | IRR_GW | ENL BAUMAN #4 | 130 |
| P79311.0W | FADJ | IRR_GW | ENL BAUMAN #5 | 113 |
| P79312.0W | FADJ | IRR_GW | ENL BAUMAN #6 | 112 |
| P79323.0W | FADJ | IRR_GW | ENL ADELS #3 | 100 |
| P79364.0W | COM | DOM_GW | ST JOSEPHS #1 | 167 |
| P79941.0W | COM | DOM_GW; STK | HOLMES #1 | 160 |
| P80.0C | FADJ | IRR_GW | BROWN #2 | 100 |
| P80047.0W | COM | DOM_GW; STK | BAUMAN RANCH DOMESTIC #1 | 80 |
| P8068.0W | FADJ | IRR_GW | MCGUIRE #3 | 90 |
| P8073.0W | FADJ | IRR_GW | SCHINZEL #1 | 100 |
| P8074.0W | FADJ | IRR_GW | ENL PONY EXPRESS #1 | 120 |
| P8076.0W | FADJ | IRR_GW | BROWN 32 #2 | 120 |
| P8077.0W | INC | IRR_GW; STK | FRITZ #1 | 110 |
| P8078.0W | COM | IRR_GW | IVA'S FARM #3 | 120 |
| P8079.0W | FADJ | IRR_GW | WELL #10 | 90 |
| P8134.0P | COM | DOM_GW | BUTLER #1 | 125 |
| P8136.0P | COM | DOM_GW; STK | MELVIN FORNSTROM #1 | 120 |
| P8138.0P | COM | DOM_GW | CARTER #1 | 350 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P8139.0P | COM | DOM_GW; STK | SNEESBY #1 | 90 |
| P8140.0P | COM | DOM_GW; STK | SCHWARTZ #1 | 98 |
| P8141.0P | COM | DOM_GW; STK | SCHWARTZ #2 | 96 |
| P8143.0P | COM | DOM_GW; STK | JAMES K. THOMPSON #2 | 80 |
| P8144.0P | COM | DOM_GW; STK | THEOBALD #1 (DEEPENED) | 310 |
| P81470.0W | COM | DOM_GW; STK | ENL THEOBALD #1 | 310 |
| P8148.0P | COM | DOM_GW; STK | MILDRED MC FANN #1 | 300 |
| P8149.0P | COM | DOM_GW; STK | SCHACHER #1 | 425 |
| P8150.0P | COM | STK | SCHACHER #2 | 200 |
| P8196.0P | COM | STK | BIRT RA 5 | 65 |
| P8198.0P | COM | STK | BARKELL #1 | 140 |
| P8199.0P | COM | DOM_GW; STK | BARKELL #2 | 125 |
| P820.0W | FADJ | IRR_GW | S. LANG #1 | 103 |
| P8200.0P | COM | DOM_GW; STK | DAVIS HOUSE WELL #1 | 465 |
| P8201.0P | COM | STK | DAVIS #1 STOCK WELL | 95 |
| P8202.0P | COM | DOM_GW; STK | SHANDERA #1 | 400 |
| P8210.0P | COM | DOM_GW | JEWELL #1 | 100 |
| P8213.0P | COM | STK | MEIER STOCK #1 | 30 |
| P82172.0W | FADJ | IRR_GW | ENL GARDNER #4 | 94 |
| P8218.0P | COM | DOM_GW; STK | FORNSTROM #1 | 125 |
| P8220.0P | COM | DOM_GW; STK | MORITZ BROS DOMESTIC #1 (DEEPENED) | 130 |
| P8221.0P | COM | STK | MORITZ BROS. #1 STOCK | 130 |
| P8222.0P | COM | STK | MORITZ BROS. STOCK #2 | 410 |
| P82386.0W | FADJ | IRR_GW | ENL BAUMAN #3 | 152 |
| P8259.0P | COM | DOM_GW | HOUSE WELL #1 | 100 |
| P8260.0P | COM | STK | STOCK WELL #1 | 100 |
| P8261.0P | COM | STK | STOCK WELL #2 | 90 |
| P8270.0P | COM | DOM_GW; STK | ANDERSON LIVESTOCK #9 | 120 |
| P8271.0P | COM | DOM_GW; STK | ANDERSON LIVESTOCK #10 | 120 |
| P8274.0P | COM | STK | BRYANT #1 | 140 |
| P8275.0P | COM | DOM_GW; STK | BRYANT #2 | 60 |
| P8276.0P | COM | DOM_GW; STK | BRYANT #3 | 126 |
| P8277.0P | COM | STK | KELLY #1 | 80 |
| P8278.0P | COM | DOM_GW; STK | KELLY #2 | 50 |
| P8279.0P | COM | STK | KELLY #3 | 50 |
| P8280.0P | COM | STK | KELLY #4 (DEEPENED) | 180 |
| P8282.0P | COM | DOM_GW; STK | YANDA #1 | 250 |
| P8283.0P | COM | DOM_GW; STK | YANDA #2 | 280 |
| P83499.0W | COM | DOM_GW; STK | GARDNER BROTHERS #1 | 140 |
| P83946.0W | FADJ | IRR_GW | 2ND ENL YOUNG #10 WELL | 110 |
| P83947.0W | FADJ | IRR_GW | 2ND ENL YOUNG #9 | 110 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P83948.0W | FADJ | IRR_GW | 2ND ENL LIVESTOCK #3 WELL | 160 |
| P83949.0W | FADJ | IRR_GW | ENL ANDERSON LIVESTOCK #5 | 125 |
| P84364.0W | INC | IRR_GW | ENL CARL G. FORNSTROM #4 | 80 |
| P84365.0W | INC | IRR_GW | ENL FORNSTROM WELL #1 | 84 |
| P84366.0W | INC | IRR_GW | ENL CARL FORNSTROM #1 | 155 |
| P846.0W | FADJ | IRR_GW | STEPHENS #1 | 125 |
| P847.0W | FADJ | IRR_GW | STEPHENS #2 | 110 |
| P8486.0W | FADJ | IRR_GW | RADKE #1 | 125 |
| P8487.0W | FADJ | IRR_GW | RADKE #2 | 205 |
| P8488.0W | FADJ | IRR_GW | RADKE #3 | 175 |
| P8489.0W | FADJ | IRR_GW | RADKE #4 | 130 |
| P8490.0W | FADJ | IRR_GW | RADKE #5 | 180 |
| P8491.0W | FADJ | IRR_GW | RADKE #6 | 240 |
| P8492.0W | FADJ | IRR_GW | RADKE #7 | 130 |
| P8493.0W | FADJ | IRR_GW | RADKE #8 | 67 |
| P8494.0W | FADJ | IRR_GW | RADKE #9 | 195 |
| P8495.0W | FADJ | IRR_GW | RADKE #10 | 152 |
| P8496.0W | FADJ | IRR_GW | RADKE #11 | 220 |
| P8497.0W | FADJ | IRR_GW | RADKE #12 | 257 |
| P8498.0W | FADJ | IRR_GW | RADKE #13 | 220 |
| P8499.0W | FADJ | IRR_GW | RADKE #14 | 295 |
| P8500.0W | FADJ | IRR_GW | RADKE #15 | 180 |
| P85265.0W | INC | MIS | PSF LTD. #1 | 200 |
| P8535.0P | COM | STK | DUNCAN #1 | 100 |
| P8536.0P | COM | DOM_GW; STK | HOCKET #1 (DEEPENED) | 160 |
| P8570.0W | COM | DOM_GW; STK | BAUMAN RANCH DOMESTIC #2 | 60 |
| P8658.0P | COM | DOM_GW; STK | HOUSE WELL #1 (DEEPEN) | 160 |
| P86907.0W | FADJ | IRR_GW | ENL BAUMAN #3 WELL | 152 |
| P87158.0W | INC | DOM_GW | ENL WISROTH #2 DOMESTIC | 80 |
| P873.0W | FADJ | IRR_GW | ANDERSON LIVESTOCK #3 | 160 |
| P88.0G | FADJ | IRR_GW | PLAMBECK #1 WELL | 83 |
| P8863.0P | COM | DOM_GW; STK | BISHOP #1 | 103 |
| P8864.0P | COM | STK | BISHOP #2 | 103 |
| P89067.0W | COM | DOM_GW; STK | JOHN GORDON #2 | 120 |
| P89125.0W | COM | DOM_GW | ROGER #1 | 140 |
| P89362.0W | COM | DOM_GW; STK | MARTIN #1 | 140 |
| P894.0W | FADJ | IRR_GW | HERBERT CAMPBELL FARM 3 WELL #4 | 108 |
| P90628.0W | COM | DOM_GW | ZOOK #1 | 140 |
| P9109.0W | COM | STK | SOUTH SECTION 17 | 120 |
| P91126.0W | COM | DOM_GW; STK | SUEBOB #1 | 135 |
| P94.0G | FADJ | IRR_GW | SMITH #2 | 100 |

| Permit Number | Status | Use | Facility | Well Depth (ft) |
|---|---|---|---|---|
| P94246.0W | COM | DOM_GW; STK | LEMBITZ #2 | 160 |
| P94413.0W | COM | DOM_GW | ELLIS #1 | 153 |
| P947.0W | FADJ | IRR_GW | MEAD #5 | 102 |
| P94877.0W | COM | DOM_GW | PORTER #4 | 120 |
| P95560.0W | COM | DOM_GW; STK | LINDA #2 | 100 |
| P95561.0W | COM | DOM_GW; STK | LINDA #3 | 100 |
| P95743.0W | COM | DOM_GW | TRUE #1 | 120 |
| P95757.0W | COM | DOM_GW | COUTTS #1 | 110 |
| P96038.0W | INC | IRR_GW | ENL. K. FORNSTROM #2 WELL | 85 |
| P96039.0W | INC | IRR_GW | 2ND ENL. K. FORNSTROM #1 | 84 |
| P96933.0W | COM | DOM_GW; STK | LINDA 1# | 90 |
| P97051.0W | COM | DOM_GW; STK | BERNHARDT #1 | 160 |
| P97195.0W | COM | DOM_GW; STK | HARRIS #1 | 100 |
| P97567.0W | COM | DOM_GW; STK | BREEDEN #II | 115 |
| P9758.0P | COM | DOM_GW | CHARLES BUTLER #1 | 96 |
| P9759.0P | COM | DOM_GW | THE BUTLER CO. #1 | 125 |
| P9760.0P | COM | STK | THE BUTLER CO. #2 | 110 |
| P97983.0W | COM | DOM_GW | SCHWAB #1 | 75 |
| P98452.0W | COM | DOM_GW; STK | PALMER #1 | 210 |
| P98689.0W | COM | DOM_GW | NUSZ #4 | 140 |
| P99054.0W | COM | DOM_GW; STK | MARTIN #1 | 140 |
| P9908.0W | FADJ | IRR_GW | GLASSBURN #1 | 165 |
| P9909.0W | FADJ | IRR_GW | WERNER #3 | 290 |
| P99146.0W | COM | DOM_GW; STK | WRIGHT #1 | 130 |
| P99851.0W | COM | DOM_GW; STK | KILEN #1 | 123 |

Source: https://seo.wyo.gov/

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# APPENDIX C—FORMATION FLUID-SAMPLING LABORATORY ANALYSIS

Lyons Formation water samples were acquired from the Juniper M-1 well using SLB's Single-Phase Reservoir Sampler (SRS) tool. The SRS tool was selected because it maintains samples in a single-phase condition as the tool is retrieved from the hole, resulting in pressurized in-situ sample conditions.

The well was perforated in the Lyons Formation between the depths of 9,165 and 9,171 ft, swabbed, and four water samples were collected from the depths of 9,066.67, 9,081.92, 9,096.26, and 9,066.67 ft. Please note that reported sample collection depths are shallower than the top of Lyons, however, only the Lyons Formation was perforated at the time of collection therefore samples are representative of the Lyons formation.

Water sample analyses are provided as attachments to this permit application:

- **Interim Report for WTC-23-009603 - Best Core Services - Analysis of the Water Flashed from the Sample Labeled Juniper M-1 1.01 9.pdf**

- **Interim Report for WTC-23-009603 - Best Core Services - Analysis of the Water Flashed from the Sample Labeled Juniper M-1 1.02 9.pdf**

- **Interim Report for WTC-23-009603 - Best Core Services - Analysis of the Water Flashed from the Sample Labeled Juniper M-1 1.03 9.pdf**

- **Interim Report for WTC-23-009603 - Best Core Services - Analysis of the Water Flashed from the Sample Labeled Juniper M-1 1.04 9.pdf**

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# INTERIM REPORT

## ANALYSIS OF THE WATER FLASHED FROM THE SAMPLE LABELED JUNIPER M-1 1.01, SAMPLE DEPTH (MD): 9066.67', PERFORATION INTERVAL: 9165' - 9171' (LYONS FORMATION)

**Best Core Services**
ATTN: Bryan Bell
111 Lake Street
Bakersfield, California 93305

**PROJECT NUMBER**
WTC-23-009603

**COMPILED BY**
Intertek Westport Technology Center

**DATE**
August 14, 2023



**List of Revisions**

| REVISION | DATE | REVISION DETAILS | AUTHOR | ISSUE |
|---|---|---|---|---|
| 0 | 8/14/2023 | - | Grant Broker | 1 |

Issuing Office: Westport Technology Center

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Table 1: Analysis of Water Flashed from the Sample Labeled Juniper M-1 1.01, Sample Depth: 9066.67', Perforation Interval: 9165' - 9171' (Lyons Formation) 4

# EXECUTIVE SUMMARY

## Introduction

At the request of Best Core Services, a custom water analysis was conducted on one water sample flashed from the sample labeled Juniper M-1 1.01, Sample Depth: 9066.67', Perforation Interval: 9165' - 9171' (Lyons Formation) (Note: the well was perforated, swabbed, and sampled at 9066.67').

## Experimental Procedures

### Ion Chromatography (IC) of Anions

The concentrations of bromide, chloride, fluoride, iodide, nitrate, nitrite, phosphate, and sulfate in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)

The concentrations of aluminium, barium, boron, cadmium, calcium, chromium, copper, iron, lead, lithium, magnesium, manganese, nickel, phosphorous, potassium, silicon, sodium, strontium, zinc, arsenic, selenium, vanadium, and uranium in the water sample were determined using Inductively Coupled Plasma Spectroscopy. It should be noted that the sample solution was diluted as required prior to analysis.

### Ion Chromatography (IC) of Organic Acids

The concentrations of acetic acid, butyric acid, formic acid, glycolic acid, propionic acid in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### pH

The pH of the water sample was determined following the procedure given in ASTM D1293.

### Alkalinity

The concentrations of carbonate and bicarbonate in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### Conductivity

The Conductivity/Resistivity of the water sample was determined following the procedure given in ASTM D1125.

### Density

The density of the water sample was determined following the procedure given in ASTM D4052.

### Total Dissolved Solids

The concentration of total dissolved solids in the water sample was determined following the procedure given in ASTM D5907.

### Total and Dissolved Organic Carbon

The concentrations of total and dissolved organic carbon in the water sample were determined following the procedure given in SM 5310C.

## Water Isotope Analysis (Hydrogen and Oxygen)

Hydrogen isotopes were measured by Isotope Ratio Mass Spectrometry (IRMS) on hydrogen gas after equilibration of the water with the hydrogen. Oxygen isotopes were measured on carbon dioxide gas by IRMS after equilibration of the water with the carbon dioxide.

## Water Isotope Analysis (Strontium Isotopes)

The water sample was treated following the protocol outlined in Environmental Science & Technology 2012 46 (6), 3545-3553. A sufficient volume of each sample (typically 1-3 mL) is acidified to a pH of 2 or less, passed through pre-cleaned 45 µm filters, and dried down in pre-cleaned Teflon beakers. The residue is taken up in approximately 1 mL of concentrated HNO3, dried again, then taken into solution in 1mL of 8M HNO3. Approximately 70 µL of this solution is then loaded onto pre-cleaned and conditioned columns containing Eichrom® Sr-Spec resin, and Sr is isolated and collected by standard ion chromatographic techniques similar to the protocol described in Geochemistry, Geophysics, Geosystems, 15, 499-508, using 8M HNO3 to strip interfering cations, followed by MilliQ water to release resin-bound Sr at the appropriate time. Column chemistry has been finely calibrated to maximize the separation of Rb from Sr, thus eliminating nearly all isobaric interference of $^{87}Rb$ in the final eluent.

Sr isotopic compositions are determined on a Nu-Plasma II MC-ICP-MS in static mode. $^{87}Sr/^{86}Sr$ ratios are corrected for mass bias using exponential law and $^{86}Sr/^{88}Sr = 0.1194$. $^{87}Sr$ is corrected for isobaric Rb by monitoring the intensity of $^{85}Rb$ and subtracting the intensity of $^{87}Rb$ from the intensity of $^{87}Sr$ using $^{87}Rb/^{85}Rb = 0.386$ and a mass bias correction factor determined from $^{86}Sr/^{88}Sr$. All analyses are corrected for isobaric interference of Kr impurities in the Ar gas by using on-peak measured zeros determined on an ultra-high purity 2% HNO . The value determined for NBS 987 and USGS BHVO-2 during the course of the day was 0.710236 ± 0.000013 (n=7) and 0.703428 ± 0.000024 (n=4), respectively.

## Water Isotope Analysis ($\delta^{13}C$ (Carbon Isotope Analysis) of Dissolved Inorganic Carbon (DIC))

The $\delta^{13}C$ of DIC is determined by injecting up to 1 ml of sample water into a helium flushed 12mL Exetainer® containing 0.1mL of 85% phosphoric acid and a magnetic spin bar. Sample size is determined based on alkalinity, which is measured by titration with 0.1N HCl.
The sample is stirred for a minimum of one hour and then allowed to equilibrate for 24 hours. At time of analysis the sample vials are placed in the GasBench tray. The $CO_2$ generated is flushed out of the vial via a two port needle. Water is removed by two nafion traps, and pure $CO_2$ is separated using a GC column. The $CO_2$/helium mixture then enters the mass spectrometer and is compared against a reference standard a total of six times.

## Water Isotope Analysis ($\delta^{14}C$ (Carbon Isotope Analysis) of Dissolved Inorganic Carbon (DIC))

The Accelerator Mass Spectrometry (AMS) measurement is done on graphite produced by hydrogen reduction of the $CO_2$ sample over a cobalt catalyst. The $CO_2$ is obtained from the combustion of the sample at 800°C under a 100% oxygen atmosphere. The $CO_2$ is first dried with methanol/dry ice then collected in liquid nitrogen for the subsequent graphitization reaction. The identical reaction is performed on reference standards, internal QA samples, and backgrounds to ensure systematic chemistry.

The analytical result ("BP" or "pMC") is obtained by measuring sample $^{14}C/^{13}C$ relative to the $^{14}C/^{13}C$ in Oxalic Acid II (NIST-4990C) in a particle accelerator using SNICS ion source. Quality assurance samples are measured along with the unknowns and reported separately in a "QA report". The radiocarbon dating lab requires results for the QA samples to fall within expectations of the known values prior to accepting and reporting the results for any given sample.

The AMS result is corrected for total fractionation using machine graphite δ13C. The δ13C reported for the sample is obtained by different ways depending upon the sample material. Solid organics are sub-sampled and converted to $CO_2$ with an elemental analyzer (EA). Water and carbonates are acidified in a gas bench to produce $CO_2$. Both the EA and the gas bench are connected directly to an isotope-ratio mass spectrometer (IRMS). The IRMS performs the separation and measurement of the $CO_2$ masses (44, 45, and 46) and calculation of the sample δ13C.

### Adenosine Triphosphate

ATP analysis was performed using the commercially available LuminUltra Quench- GoneTM Aqueous Test Kit. The kit measured the ATP contained within living cells using the firefly luciferase assay through measurement of the intensity of light by a luminometer. The intensity of light was correlated to the cell concentration by means of a standard of known cell concentration. The cell concentration was converted into units of Microbial Equivalents based on the cell size of e-coli bacteria.

### Concentrations of Bacteria

The concentrations of Iron Related Bacteria (IRB), Sulfate Reducing Bacteria (SRB), and Slime Forming Bacteria (SLYM) in the water sample were determined using BART Test kits.

### Gas Isotope Analysis ($\delta^{13}C$ (Carbon Isotope Analysis) of Methane and Carbon Dioxide

Samples were analyzed for carbon isotope composition of methane and carbon dioxide by continuous flow gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) using a Thermo Delta V Plus IRMS outfitted with an Agilent 7890A GC, GC Isolink, and Conflo IV. Results were corrected to known standards and expressed as ppt vs. VPDB.

## Results and Discussion

The results of the custom water analysis are presented in Table 1.

**Table 1: Analysis of Water Flashed from the Sample Labeled Juniper M-1 1.01, Sample Depth: 9066.67', Perforation Interval: 9165' - 9171' (Lyons Formation)**

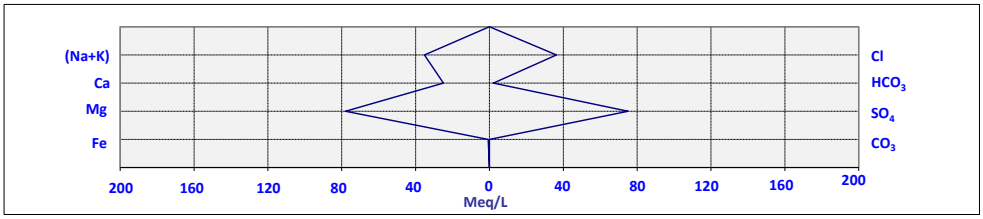
| | Cations | | Test Method | (mg/L) | MW | Valence | Factor | Meq/L |
|---|---|---|---|---|---|---|---|---|
| 1 | Aluminium | $Al^{3+}$ | ICP | <0.1 | 27.0 | 3 | 9.0 | n/a |
| 2 | Ammonium | $NH_4^+$ | ICP | NT | 18.0 | 1 | 18.0 | n/a |
| 3 | Barium | $Ba^{2+}$ | ICP | <0.1 | 89.1 | 2 | 44.6 | n/a |
| 4 | Boron | $B^{3+}$ | ICP | 49.8 | 10.8 | 3 | 3.6 | 13.8 |
| 5 | Cadmium | $Cd^{2+}$ | ICP | <0.1 | 112.4 | 2 | 56.2 | n/a |
| 6 | Calcium | $Ca^{2+}$ | ICP | 499.8 | 40.1 | 2 | 20.0 | 24.9 |
| 7 | Copper | $Cu^{2+}$ | ICP | 0.8 | 63.5 | 2 | 31.8 | 0.0 |
| 8 | Chromium | $Cr^{3+}$ | ICP | <0.1 | 52.0 | 3 | 17.3 | n/a |
| 9 | Iron (total) | $Fe^{2+}$ | ICP | 17.6 | 55.8 | 2 | 27.9 | 0.6 |
| 10 | Lead | $Pb^{2+}$ | ICP | <0.1 | 207.2 | 2 | 103.6 | n/a |
| 11 | Lithium | $Li^+$ | ICP | 13.9 | 6.9 | 1 | 6.9 | 2.0 |
| 12 | Magnesium | $Mg^{2+}$ | ICP | 947.7 | 24.3 | 2 | 12.2 | 78.0 |
| 13 | Manganese | $Mn^{2+}$ | ICP | 2.0 | 54.9 | 2 | 27.5 | 0.1 |
| 14 | Nickel | $Ni^{2+}$ | ICP | <0.1 | 58.7 | 2 | 29.4 | n/a |
| 15 | Phosphorus | $P^{3+}$ | ICP | <0.1 | 31.0 | 3 | 10.3 | n/a |
| 16 | Potassium | $K^+$ | ICP | 2563.7 | 39.1 | 1 | 39.1 | 65.6 |
| 17 | Silicon | $Si^{4+}$ | ICP | 19.9 | 28.1 | 4 | 7.0 | 2.8 |
| 18 | Sodium | $Na^+$ | ICP | 79384.3 | 23.0 | 1 | 23.0 | 3453.0 |
| 19 | Strontium | $Sr^{2+}$ | ICP | 13.1 | 87.6 | 2 | 43.8 | 0.3 |
| 20 | Zinc | $Zn^{2+}$ | ICP | 4.7 | 65.4 | 2 | 32.7 | 0.1 |

| | Anions | | Test Method | (mg/L) | MW | Valence | Factor | Meq/L |
|---|---|---|---|---|---|---|---|---|
| 1 | Acetate | $CH_3COO^-$ | IC | < 0.5 | 59.0 | 1 | 59.0 | n/a |
| 2 | Bicarbonate | $HCO_3^-$ | IC | 130.0 | 61.0 | 1 | 61.0 | 2.1 |
| 3 | Bromide | $Br^-$ | IC | 48.8 | 79.9 | 1 | 79.9 | 0.6 |
| 4 | Butyrate | $CH3CH_3CH_2CO_2^-$ | IC | < 0.5 | 88.1 | 1 | 88.1 | n/a |
| 5 | Carbonate | $CO_3^{2-}$ | IC | 0.0 | 60.0 | 2 | 30.0 | 0.0 |
| 6 | Chloride | $Cl^-$ | IC | 128975.5 | 35.5 | 1 | 35.5 | 3633.1 |
| 7 | Fluoride | $F^-$ | IC | < 0.1 | 19.0 | 1 | 19.0 | n/a |
| 8 | Formate | $HCOO^-$ | IC | < 0.5 | 45.0 | 1 | 45.0 | n/a |
| 9 | Glycolate | $OHCCOO^-$ | IC | < 0.5 | 76.1 | 1 | 76.1 | n/a |
| 10 | Hydroxide | $OH^-$ | Titration | 0.0 | 17.0 | 1 | 17.0 | 0.0 |
| 11 | Iodide | I- | IC | < 0.5 | 126.9 | 1 | 126.9 | 0.6 |
| 12 | Nitrate | $NO_3^-$ | IC | < 0.5 | 62.0 | 1 | 62.0 | n/a |
| 13 | Nitrite | $NO_2^-$ | IC | 1.3 | 46.0 | 1 | 46.0 | 0.0 |
| 14 | Phosphate | $PO_4^{3-}$ | IC | <0.5 | 95.0 | 3 | 31.7 | n/a |
| 15 | Propionate | $CH_3CH_2CO_2^-$ | IC | < 0.5 | 73.1 | 1 | 73.1 | n/a |
| 16 | Sulphate | $SO_4^{2-}$ | IC | 3607.4 | 96.1 | 2 | 48.0 | 75.1 |

| | |
|---|---|
| **Total Cation Meq's** | **3641** |
| **Ion Balance** | **0.981** |

| | |
|---|---|
| **Total Anion Meq's** | **3712** |

**Stiff Diagram**




| | |
|---|---|
| pH | 6.45 |
| Conductivity, mS/cm @ 25 °C | 251.5 |
| Hardness, ppm | 5,145 |
| Salinity, g/Kg | 226.0 |
| Density (g/cm$^3$ @ 20 °C) | 1.1671 |
| δD H2O (‰ vs VSMOW) | -46.38 |
| δO H2O (‰ vs VSMOW) | -3.73 |
| Strontium Isotopes ($^{87}Sr/^{86}Sr$) | pending |
| $\delta^{13}C$ of DIC (‰ vs VPDB) | pending |
| $\delta^{14}C$ Content of DIC (% modern Carbon) | pending |
| Concentration of Dissolved Organic Carbon (DOC), mg/L | 1.06 |
| $\delta^{13}C$ of Methane in the flashed gas (‰ vs. VPDB)[1] | -36.927 |
| CATP, ME/mL | 1.6 x 10$^3$ |
| Concentration of Sulfate Reducing | < 1.0 |

[1]The concentration of Methane in the sample was below 2000 ppm resulting in the reliability of the isotopes being lower than anticipated.

| | |
|---|---|
| TDS (Calculated), mg/L | 216,280 |
| TDS (Gravimetric), mg/L | 226,008 |
| Resistivity, Ohm-cm @ 25 °C | 3.98 |
| Total Alkalinity, mg $CaCO_3$/L | 150 |
| Concentration of carbonate by Titration, mg/L | 0 |
| Concentration of bicarbonate by Titration, mg/L | 183 |
| Concentration of Vanadium, mg/L | < 0.1 |
| Concentration of Selenium, mg/L | <0.1 |
| Concentration of Arsenic, mg/L | < 0.1 |
| Concentration of Total Organic Carbon (TOC), mg/L | 1.06 |
| Concentration of Uranium, mg/L | < 0.1 |
| δ13C of Carbon Dioxide in the flashed gas(‰ vs. VPDB) | -9.443 |
| Concentration of Iron Related Bacteria, cfu/mL | < 1.0 |
| Concentration of Slime Forming Bacteria, cfu/mL | < 20 |

ICP: Inductively Coupled Plasma IC: Ion Chromatography NT: Not Tested

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# INTERIM REPORT

## ANALYSIS OF THE WATER FLASHED FROM THE SAMPLE LABELED JUNIPER M-1 1.02, SAMPLE DEPTH: 9081.92', PERFORATION INTERVAL: 9165' - 9171' (LYONS FORMATION)

**Best Core Services**
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111 Lake Street
Bakersfield, California 93305

**PROJECT NUMBER**
WTC-23-009603

**COMPILED BY**
Intertek Westport Technology Center

**DATE**
August 14, 2023



**List of Revisions**

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Issuing Office: Westport Technology Center

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Table 1: Analysis of Water Flashed from the Sample Labeled Juniper M-1 1.02, Sample Depth: 9081.92', Perforation Interval: 9165' - 9171' (Lyons Formation) 4

# EXECUTIVE SUMMARY

## Introduction

At the request of Best Core Services, a custom water analysis was conducted on one water sample flashed from the sample labeled Juniper M-1 1.02, Sample Depth: 9081.92', Perforation Interval: 9165' - 9171' (Lyons Formation) (Note: the well was perforated, swabbed, and sampled at 9081.92').

## Experimental Procedures

### Ion Chromatography (IC) of Anions

The concentrations of bromide, chloride, fluoride, iodide, nitrate, nitrite, phosphate, and sulfate in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)

The concentrations of aluminium, barium, boron, cadmium, calcium, chromium, copper, iron, lead, lithium, magnesium, manganese, nickel, phosphorous, potassium, silicon, sodium, strontium, zinc, arsenic, selenium, vanadium, and uranium in the water sample were determined using Inductively Coupled Plasma Spectroscopy. It should be noted that the sample solution was diluted as required prior to analysis.

### Ion Chromatography (IC) of Organic Acids

The concentrations of acetic acid, butyric acid, formic acid, glycolic acid, propionic acid in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### pH

The pH of the water sample was determined following the procedure given in ASTM D1293.

### Alkalinity

The concentrations of carbonate and bicarbonate in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### Conductivity

The Conductivity/Resistivity of the water sample was determined following the procedure given in ASTM D1125.

### Density

The density of the water sample was determined following the procedure given in ASTM D4052.

### Total Dissolved Solids

The concentration of total dissolved solids in the water sample was determined following the procedure given in ASTM D5907.

### Total and Dissolved Organic Carbon

The concentrations of total and dissolved organic carbon in the water sample were determined following the procedure given in SM 5310C.

## Water Isotope Analysis (Hydrogen and Oxygen)

Hydrogen isotopes were measured by Isotope Ratio Mass Spectrometry (IRMS) on hydrogen gas after equilibration of the water with the hydrogen. Oxygen isotopes were measured on carbon dioxide gas by IRMS after equilibration of the water with the carbon dioxide.

## Water Isotope Analysis (Strontium Isotopes)

The water sample was treated following the protocol outlined in Environmental Science & Technology 2012 46 (6), 3545-3553. A sufficient volume of each sample (typically 1-3 mL) is acidified to a pH of 2 or less, passed through pre-cleaned 45 µm filters, and dried down in pre-cleaned Teflon beakers. The residue is taken up in approximately 1 mL of concentrated HNO3, dried again, then taken into solution in 1mL of 8M HNO3. Approximately 70 µL of this solution is then loaded onto pre-cleaned and conditioned columns containing Eichrom® Sr-Spec resin, and Sr is isolated and collected by standard ion chromatographic techniques similar to the protocol described in Geochemistry, Geophysics, Geosystems, 15, 499-508, using 8M HNO3 to strip interfering cations, followed by MilliQ water to release resin-bound Sr at the appropriate time. Column chemistry has been finely calibrated to maximize the separation of Rb from Sr, thus eliminating nearly all isobaric interference of $^{87}$Rb in the final eluent.

Sr isotopic compositions are determined on a Nu-Plasma II MC-ICP-MS in static mode. $^{87}Sr/^{86}Sr$ ratios are corrected for mass bias using exponential law and $^{86}Sr/^{88}Sr = 0.1194$. $^{87}$Sr is corrected for isobaric Rb by monitoring the intensity of $^{85}$Rb and subtracting the intensity of $^{87}$Rb from the intensity of $^{87}$Sr using $^{87}Rb/^{85}Rb = 0.386$ and a mass bias correction factor determined from $^{86}Sr/^{88}Sr$. All analyses are corrected for isobaric interference of Kr impurities in the Ar gas by using on-peak measured zeros determined on an ultra-high purity 2% HNO . The value determined for NBS 987 and USGS BHVO-2 during the course of the day was 0.710236 ± 0.000013 (n=7) and 0.703428 ± 0.000024 (n=4), respectively.

## Water Isotope Analysis ($\delta^{13}$C (Carbon Isotope Analysis) of Dissolved Inorganic Carbon (DIC))

The $\delta^{13}$C of DIC is determined by injecting up to 1 ml of sample water into a helium flushed 12mL Exetainer® containing 0.1mL of 85% phosphoric acid and a magnetic spin bar. Sample size is determined based on alkalinity, which is measured by titration with 0.1N HCl.

The sample is stirred for a minimum of one hour and then allowed to equilibrate for 24 hours. At time of analysis the sample vials are placed in the GasBench tray. The $CO_2$ generated is flushed out of the vial via a two port needle. Water is removed by two nafion traps, and pure $CO_2$ is separated using a GC column. The $CO_2$/helium mixture then enters the mass spectrometer and is compared against a reference standard a total of six times.

## Water Isotope Analysis ($\delta^{14}C$ (Carbon Isotope Analysis) of Dissolved Inorganic Carbon (DIC))

The Accelerator Mass Spectrometry (AMS) measurement is done on graphite produced by hydrogen reduction of the $CO_2$ sample over a cobalt catalyst. The $CO_2$ is obtained from the combustion of the sample at 800°C under a 100% oxygen atmosphere. The $CO_2$ is first dried with methanol/dry ice then collected in liquid nitrogen for the subsequent graphitization reaction. The identical reaction is performed on reference standards, internal QA samples, and backgrounds to ensure systematic chemistry.

The analytical result ("BP" or "pMC") is obtained by measuring sample $^{14}C/^{13}C$ relative to the $^{14}C/^{13}C$ in Oxalic Acid II (NIST-4990C) in a particle accelerator using SNICS ion source. Quality assurance samples are measured along with the unknowns and reported separately in a "QA report". The radiocarbon dating lab requires results for the QA samples to fall within expectations of the known values prior to accepting and reporting the results for any given sample.

The AMS result is corrected for total fractionation using machine graphite δ13C. The δ13C reported for the sample is obtained by different ways depending upon the sample material. Solid organics are sub-sampled and converted to $CO_2$ with an elemental analyzer (EA). Water and carbonates are acidified in a gas bench to produce $CO_2$. Both the EA and the gas bench are connected directly to an isotope-ratio mass spectrometer (IRMS). The IRMS performs the separation and measurement of the $CO_2$ masses (44, 45, and 46) and calculation of the sample δ13C.

## Gas Isotope Analysis ($\delta^{13}C$ (Carbon Isotope Analysis) of Methane and Carbon Dioxide

Samples were analyzed for carbon isotope composition of methane and carbon dioxide by continuous flow gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) using a Thermo Delta V Plus IRMS outfitted with an Agilent 7890A GC, GC Isolink, and Conflo IV. Results were corrected to known standards and expressed as ppt vs. VPDB.

## Results and Discussion

The results of the custom water analysis are presented in Table 1.

**Table 1: Analysis of Water Flashed from the Sample Labeled Juniper M-1 1.02, Sample Depth: 9081.92', Perforation Interval: 9165' - 9171' (Lyons Formation)**

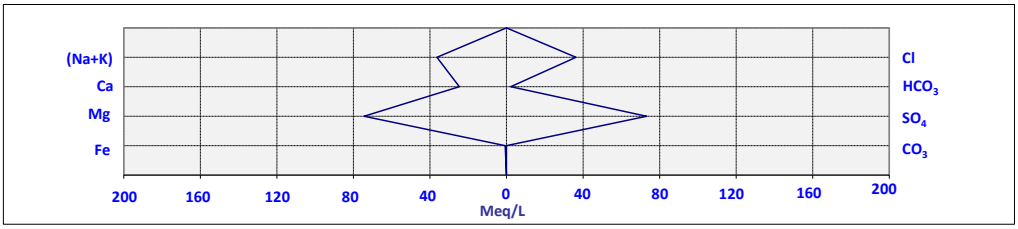
| | Cations | | Test Method | (mg/L) | MW | Valence | Factor | Meq/L |
|---|---|---|---|---|---|---|---|---|
| 1 | Aluminium | $Al^{3+}$ | ICP | <0.1 | 27.0 | 3 | 9.0 | n/a |
| 2 | Ammonium | $NH_4^+$ | ICP | NT | 18.0 | 1 | 18.0 | n/a |
| 3 | Barium | $Ba^{2+}$ | ICP | <0.1 | 89.1 | 2 | 44.6 | n/a |
| 4 | Boron | $B^{3+}$ | ICP | 47.3 | 10.8 | 3 | 3.6 | 13.1 |
| 5 | Cadmium | $Cd^{2+}$ | ICP | <0.1 | 112.4 | 2 | 56.2 | n/a |
| 6 | Calcium | $Ca^{2+}$ | ICP | 495.1 | 40.1 | 2 | 20.0 | 24.7 |
| 7 | Copper | $Cu^{2+}$ | ICP | 0.9 | 63.5 | 2 | 31.8 | 0.0 |
| 8 | Chromium | $Cr^{3+}$ | ICP | <0.1 | 52.0 | 3 | 17.3 | n/a |
| 9 | Iron (total) | $Fe^{2+}$ | ICP | 18.4 | 55.8 | 2 | 27.9 | 0.7 |
| 10 | Lead | $Pb^{2+}$ | ICP | 0.3 | 207.2 | 2 | 103.6 | 0.0 |
| 11 | Lithium | $Li^+$ | ICP | 13.2 | 6.9 | 1 | 6.9 | 1.9 |
| 12 | Magnesium | $Mg^{2+}$ | ICP | 904.4 | 24.3 | 2 | 12.2 | 74.4 |
| 13 | Manganese | $Mn^{2+}$ | ICP | 2.0 | 54.9 | 2 | 27.5 | 0.1 |
| 14 | Nickel | $Ni^{2+}$ | ICP | <0.1 | 58.7 | 2 | 29.4 | n/a |
| 15 | Phosphorus | $P^{3+}$ | ICP | <0.1 | 31.0 | 3 | 10.3 | n/a |
| 16 | Potassium | $K^+$ | ICP | 2529.4 | 39.1 | 1 | 39.1 | 64.7 |
| 17 | Silicon | $Si^{4+}$ | ICP | 18.1 | 28.1 | 4 | 7.0 | 2.6 |
| 18 | Sodium | $Na^+$ | ICP | 82174.7 | 23.0 | 1 | 23.0 | 3574.4 |
| 19 | Strontium | $Sr^{2+}$ | ICP | 12.6 | 87.6 | 2 | 43.8 | 0.3 |
| 20 | Zinc | $Zn^{2+}$ | ICP | 3.5 | 65.4 | 2 | 32.7 | 0.1 |

| | Anions | | Test Method | (mg/L) | MW | Valence | Factor | Meq/L |
|---|---|---|---|---|---|---|---|---|
| 1 | Acetate | $CH_3COO^-$ | IC | < 0.5 | 59.0 | 1 | 59.0 | n/a |
| 2 | Bicarbonate | $HCO_3^-$ | IC | 133.6 | 61.0 | 1 | 61.0 | 2.2 |
| 3 | Bromide | $Br^-$ | IC | 49.2 | 79.9 | 1 | 79.9 | 0.6 |
| 4 | Butyrate | $CH3CH_3CH_2CO_2^-$ | IC | < 0.5 | 88.1 | 1 | 88.1 | n/a |
| 5 | Carbonate | $CO_3^{2-}$ | IC | 0.0 | 60.0 | 2 | 30.0 | 0.0 |
| 6 | Chloride | $Cl^-$ | IC | 128665.6 | 35.5 | 1 | 35.5 | 3624.4 |
| 7 | Fluoride | $F^-$ | IC | < 0.1 | 19.0 | 1 | 19.0 | n/a |
| 8 | Formate | $HCOO^-$ | IC | < 0.5 | 45.0 | 1 | 45.0 | n/a |
| 9 | Glycolate | $OHCCOO^-$ | IC | < 0.5 | 76.1 | 1 | 76.1 | n/a |
| 10 | Hydroxide | $OH^-$ | Titration | 0.0 | 17.0 | 1 | 17.0 | 0.0 |
| 11 | Iodide | I- | IC | < 0.5 | 126.9 | 1 | 126.9 | 0.6 |
| 12 | Nitrate | $NO_3^-$ | IC | < 0.5 | 62.0 | 1 | 62.0 | n/a |
| 13 | Nitrite | $NO_2^-$ | IC | 4.5 | 46.0 | 1 | 46.0 | 0.1 |
| 14 | Phosphate | $PO_4^{3-}$ | IC | <0.5 | 95.0 | 3 | 31.7 | n/a |
| 15 | Propionate | $CH_3CH_2CO_2^-$ | IC | < 0.5 | 73.1 | 1 | 73.1 | n/a |
| 16 | Sulphate | $SO_4^{2-}$ | IC | 3515.2 | 96.1 | 2 | 48.0 | 73.2 |

| | |
|---|---|
| **Total Cation Meq's** | **3757** |
| **Ion Balance** | **1.015** |

| | |
|---|---|
| **Total Anion Meq's** | **3701** |

**Stiff Diagram**




| | |
|---|---|
| pH | 6.36 |
| Conductivity, mS/cm @ 25 °C | 251.3 |
| Hardness, ppm | 4,955 |
| Salinity, g/Kg | 225.0 |
| Density (g/cm$^3$ @ 20 °C) | 1.1675 |
| δD H2O (‰ vs VSMOW) | -44.29 |
| δO H2O (‰ vs VSMOW) | -6.99 |
| Strontium Isotopes ($^{87}Sr/^{86}Sr$) | pending |
| $\delta^{13}C$ of DIC (‰ vs VPDB) | pending |
| $\delta^{14}C$ Content of DIC (% modern Carbon) | pending |
| Concentration of Dissolved Organic Carbon (DOC), mg/L | 1.04 |
| $\delta^{13}C$ of Methane in the flashed gas (‰ vs. VPDB)[1] | - |

| | |
|---|---|
| TDS (Calculated), mg/L | 216,280 |
| TDS (Gravimetric), mg/L | 224,800 |
| Resistivity, Ohm-cm @ 25 °C | 3.98 |
| Total Alkalinity, mg $CaCO_3$/L | 154 |
| Concentration of carbonate by Titration, mg/L | 0 |
| Concentration of bicarbonate by Titration, mg/L | 187.9 |
| Concentration of Vanadium, mg/L | < 0.1 |
| Concentration of Selenium, mg/L | <0.1 |
| Concentration of Arsenic, mg/L | < 0.1 |
| Concentration of Total Organic Carbon (TOC), mg/L | 1.04 |
| Concentration of Uranium, mg/L | < 0.1 |
| δ13C of Carbon Dioxide in the flashed gas(‰ vs. VPDB) | -8.623 |

[1]The concentration of Methane in the sample was too low to measure the methane isotopes

ICP: Inductively Coupled Plasma IC: Ion Chromatography NT: Not Tested

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# INTERIM REPORT

## ANALYSIS OF THE WATER FLASHED FROM THE SAMPLE LABELED JUNIPER M-1 1.03 SAMPLE DEPTH: 9096.26', PERFORATION INTERVAL: 9165' - 9171' (LYONS FORMATION)

**Best Core Services**
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Bakersfield, California 93305

**PROJECT NUMBER**
WTC-23-009603

**COMPILED BY**
Intertek Westport Technology Center

**DATE**
August 14, 2023



**List of Revisions**

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Issuing Office: Westport Technology Center

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Table 1: Analysis of Water Flashed from the Sample Labeled Juniper M-1 1.03, Sample Depth: 9096.26', Perforation Interval: 9165' - 9171' (Lyons Formation) 4

# EXECUTIVE SUMMARY

## Introduction

At the request of Best Core Services, a custom water analysis was conducted on one water sample flashed from the sample labeled Juniper M-1 1.03, Sample Depth: 9096.26', Perforation Interval: 9165' - 9171' (Lyons Formation) (Note: the well was perforated, swabbed, and sampled at 9096.26').

## Experimental Procedures

### Ion Chromatography (IC) of Anions

The concentrations of bromide, chloride, fluoride, iodide, nitrate, nitrite, phosphate, and sulfate in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)

The concentrations of aluminium, barium, boron, cadmium, calcium, chromium, copper, iron, lead, lithium, magnesium, manganese, nickel, phosphorous, potassium, silicon, sodium, strontium, zinc, arsenic, selenium, vanadium, and uranium in the water sample were determined using Inductively Coupled Plasma Spectroscopy. It should be noted that the sample solution was diluted as required prior to analysis.

### Ion Chromatography (IC) of Organic Acids

The concentrations of acetic acid, butyric acid, formic acid, glycolic acid, propionic acid in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### pH

The pH of the water sample was determined following the procedure given in ASTM D1293.

### Alkalinity

The concentrations of carbonate and bicarbonate in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### Conductivity

The Conductivity/Resistivity of the water sample was determined following the procedure given in ASTM D1125.

### Density

The density of the water sample was determined following the procedure given in ASTM D4052.

### Total Dissolved Solids

The concentration of total dissolved solids in the water sample was determined following the procedure given in ASTM D5907.

### Total and Dissolved Organic Carbon

The concentrations of total and dissolved organic carbon in the water sample were determined following the procedure given in SM 5310C.

## Water Isotope Analysis (Hydrogen and Oxygen)

Hydrogen isotopes were measured by Isotope Ratio Mass Spectrometry (IRMS) on hydrogen gas after equilibration of the water with the hydrogen. Oxygen isotopes were measured on carbon dioxide gas by IRMS after equilibration of the water with the carbon dioxide.

## Water Isotope Analysis (Strontium Isotopes)

The water sample was treated following the protocol outlined in Environmental Science & Technology 2012 46 (6), 3545-3553. A sufficient volume of each sample (typically 1-3 mL) is acidified to a pH of 2 or less, passed through pre-cleaned 45 µm filters, and dried down in pre-cleaned Teflon beakers. The residue is taken up in approximately 1 mL of concentrated HNO3, dried again, then taken into solution in 1mL of 8M HNO3. Approximately 70 µL of this solution is then loaded onto pre-cleaned and conditioned columns containing Eichrom® Sr-Spec resin, and Sr is isolated and collected by standard ion chromatographic techniques similar to the protocol described in Geochemistry, Geophysics, Geosystems, 15, 499-508, using 8M HNO3 to strip interfering cations, followed by MilliQ water to release resin-bound Sr at the appropriate time. Column chemistry has been finely calibrated to maximize the separation of Rb from Sr, thus eliminating nearly all isobaric interference of $^{87}$Rb in the final eluent.

Sr isotopic compositions are determined on a Nu-Plasma II MC-ICP-MS in static mode. $^{87}Sr/^{86}Sr$ ratios are corrected for mass bias using exponential law and $^{86}Sr/^{88}Sr = 0.1194$. $^{87}$Sr is corrected for isobaric Rb by monitoring the intensity of $^{85}$Rb and subtracting the intensity of $^{87}$Rb from the intensity of $^{87}$Sr using $^{87}Rb/^{85}Rb = 0.386$ and a mass bias correction factor determined from $^{86}Sr/^{88}Sr$. All analyses are corrected for isobaric interference of Kr impurities in the Ar gas by using on-peak measured zeros determined on an ultra-high purity 2% HNO . The value determined for NBS 987 and USGS BHVO-2 during the course of the day was 0.710236 ± 0.000013 (n=7) and 0.703428 ± 0.000024 (n=4), respectively.

## Water Isotope Analysis ($\delta^{13}$C (Carbon Isotope Analysis) of Dissolved Inorganic Carbon (DIC))

The $\delta^{13}$C of DIC is determined by injecting up to 1 ml of sample water into a helium flushed 12mL Exetainer® containing 0.1mL of 85% phosphoric acid and a magnetic spin bar. Sample size is determined based on alkalinity, which is measured by titration with 0.1N HCl.
The sample is stirred for a minimum of one hour and then allowed to equilibrate for 24 hours. At time of analysis the sample vials are placed in the GasBench tray. The $CO_2$ generated is flushed out of the vial via a two port needle. Water is removed by two nafion traps, and pure $CO_2$ is separated using a GC column. The $CO_2$/helium mixture then enters the mass spectrometer and is compared against a reference standard a total of six times.

## Water Isotope Analysis ($\delta^{14}C$ (Carbon Isotope Analysis) of Dissolved Inorganic Carbon (DIC))

The Accelerator Mass Spectrometry (AMS) measurement is done on graphite produced by hydrogen reduction of the $CO_2$ sample over a cobalt catalyst. The $CO_2$ is obtained from the combustion of the sample at 800°C under a 100% oxygen atmosphere. The $CO_2$ is first dried with methanol/dry ice then collected in liquid nitrogen for the subsequent graphitization reaction. The identical reaction is performed on reference standards, internal QA samples, and backgrounds to ensure systematic chemistry.

The analytical result ("BP" or "pMC") is obtained by measuring sample $^{14}C/^{13}C$ relative to the $^{14}C/^{13}C$ in Oxalic Acid II (NIST-4990C) in a particle accelerator using SNICS ion source. Quality assurance samples are measured along with the unknowns and reported separately in a "QA report". The radiocarbon dating lab requires results for the QA samples to fall within expectations of the known values prior to accepting and reporting the results for any given sample.

The AMS result is corrected for total fractionation using machine graphite δ13C. The δ13C reported for the sample is obtained by different ways depending upon the sample material. Solid organics are sub-sampled and converted to $CO_2$ with an elemental analyzer (EA). Water and carbonates are acidified in a gas bench to produce $CO_2$. Both the EA and the gas bench are connected directly to an isotope-ratio mass spectrometer (IRMS). The IRMS performs the separation and measurement of the $CO_2$ masses (44, 45, and 46) and calculation of the sample δ13C.

## Gas Isotope Analysis ($\delta^{13}C$ (Carbon Isotope Analysis) of Methane and Carbon Dioxide

Samples were analyzed for carbon isotope composition of methane and carbon dioxide by continuous flow gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) using a Thermo Delta V Plus IRMS outfitted with an Agilent 7890A GC, GC Isolink, and Conflo IV. Results were corrected to known standards and expressed as ppt vs. VPDB.

## Results and Discussion

The results of the custom water analysis are presented in Table 1.

**Table 1: Analysis of Water Flashed from the Sample Labeled Juniper M-1 1.03, Sample Depth: 9096.26', Perforation Interval: 9165' - 9171' (Lyons Formation)**

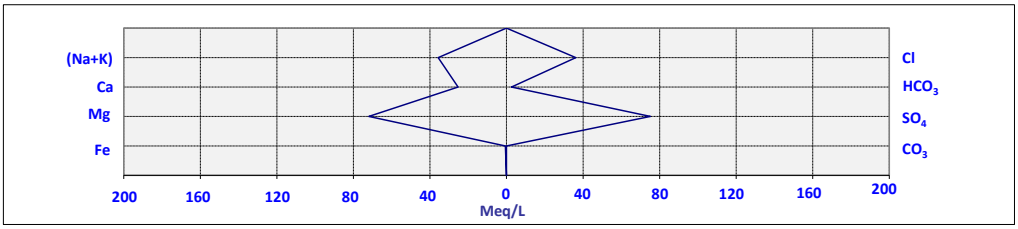
| | Cations | | Test Method | (mg/L) | MW | Valence | Factor | Meq/L |
|---|---|---|---|---|---|---|---|---|
| 1 | Aluminium | $Al^{3+}$ | ICP | <0.1 | 27.0 | 3 | 9.0 | n/a |
| 2 | Ammonium | $NH_4^+$ | ICP | NT | 18.0 | 1 | 18.0 | n/a |
| 3 | Barium | $Ba^{2+}$ | ICP | <0.1 | 89.1 | 2 | 44.6 | n/a |
| 4 | Boron | $B^{3+}$ | ICP | 45.7 | 10.8 | 3 | 3.6 | 12.7 |
| 5 | Cadmium | $Cd^{2+}$ | ICP | <0.1 | 112.4 | 2 | 56.2 | n/a |
| 6 | Calcium | $Ca^{2+}$ | ICP | 508.1 | 40.1 | 2 | 20.0 | 25.4 |
| 7 | Copper | $Cu^{2+}$ | ICP | <0.1 | 63.5 | 2 | 31.8 | n/a |
| 8 | Chromium | $Cr^{3+}$ | ICP | <0.1 | 52.0 | 3 | 17.3 | n/a |
| 9 | Iron (total) | $Fe^{2+}$ | ICP | 17.9 | 55.8 | 2 | 27.9 | 0.6 |
| 10 | Lead | $Pb^{2+}$ | ICP | <0.1 | 207.2 | 2 | 103.6 | n/a |
| 11 | Lithium | $Li^+$ | ICP | 14.9 | 6.9 | 1 | 6.9 | 2.1 |
| 12 | Magnesium | $Mg^{2+}$ | ICP | 874.4 | 24.3 | 2 | 12.2 | 72.0 |
| 13 | Manganese | $Mn^{2+}$ | ICP | 2.0 | 54.9 | 2 | 27.5 | 0.1 |
| 14 | Nickel | $Ni^{2+}$ | ICP | <0.1 | 58.7 | 2 | 29.4 | n/a |
| 15 | Phosphorus | $P^{3+}$ | ICP | <0.1 | 31.0 | 3 | 10.3 | n/a |
| 16 | Potassium | $K^+$ | ICP | 2425.6 | 39.1 | 1 | 39.1 | 62.0 |
| 17 | Silicon | $Si^{4+}$ | ICP | 19.6 | 28.1 | 4 | 7.0 | 2.8 |
| 18 | Sodium | $Na^+$ | ICP | 80733.7 | 23.0 | 1 | 23.0 | 3511.7 |
| 19 | Strontium | $Sr^{2+}$ | ICP | 12.5 | 87.6 | 2 | 43.8 | 0.3 |
| 20 | Zinc | $Zn^{2+}$ | ICP | 3.6 | 65.4 | 2 | 32.7 | 0.1 |

| | Anions | | Test Method | (mg/L) | MW | Valence | Factor | Meq/L |
|---|---|---|---|---|---|---|---|---|
| 1 | Acetate | $CH_3COO^-$ | IC | < 0.5 | 59.0 | 1 | 59.0 | n/a |
| 2 | Bicarbonate | $HCO_3^-$ | IC | 159.9 | 61.0 | 1 | 61.0 | 2.6 |
| 3 | Bromide | $Br^-$ | IC | 49.4 | 79.9 | 1 | 79.9 | 0.6 |
| 4 | Butyrate | $CH3CH_3CH_2CO_2^-$ | IC | < 0.5 | 88.1 | 1 | 88.1 | n/a |
| 5 | Carbonate | $CO_3^{2-}$ | IC | 0.0 | 60.0 | 2 | 30.0 | 0.0 |
| 6 | Chloride | $Cl^-$ | IC | 128580.5 | 35.5 | 1 | 35.5 | 3622.0 |
| 7 | Fluoride | $F^-$ | IC | < 0.1 | 19.0 | 1 | 19.0 | n/a |
| 8 | Formate | $HCOO^-$ | IC | < 0.5 | 45.0 | 1 | 45.0 | n/a |
| 9 | Glycolate | $OHCCOO^-$ | IC | < 0.5 | 76.1 | 1 | 76.1 | n/a |
| 10 | Hydroxide | $OH^-$ | Titration | 0.0 | 17.0 | 1 | 17.0 | 0.0 |
| 11 | Iodide | I- | IC | < 0.5 | 126.9 | 1 | 126.9 | 0.6 |
| 12 | Nitrate | $NO_3^-$ | IC | < 0.5 | 62.0 | 1 | 62.0 | n/a |
| 13 | Nitrite | $NO_2^-$ | IC | 1.5 | 46.0 | 1 | 46.0 | 0.0 |
| 14 | Phosphate | $PO_4^{3-}$ | IC | <0.5 | 95.0 | 3 | 31.7 | n/a |
| 15 | Propionate | $CH_3CH_2CO_2^-$ | IC | < 0.5 | 73.1 | 1 | 73.1 | n/a |
| 16 | Sulphate | $SO_4^{2-}$ | IC | 3609.8 | 96.1 | 2 | 48.0 | 75.2 |

| | |
|---|---|
| **Total Cation Meq's** | **3690** |
| **Ion Balance** | **0.997** |

| | |
|---|---|
| **Total Anion Meq's** | **3701** |

**Stiff Diagram**




| | |
|---|---|
| pH | 6.43 |
| Conductivity, mS/cm @ 25 °C | 251.5 |
| Hardness, ppm | 4,955 |
| Salinity, g/Kg | 226.0 |
| Density ($g/cm^3$ @ 20 °C) | 1.168 |
| δD H2O (‰ vs VSMOW) | -40.66 |
| δO H2O (‰ vs VSMOW) | -7.33 |
| Strontium Isotopes ($^{87}Sr/^{86}Sr$) | pending |
| $\delta^{13}C$ of DIC (‰ vs VPDB) | pending |
| $\delta^{14}C$ Content of DIC (% modern Carbon) | pending |
| Concentration of Dissolved Organic Carbon (DOC), mg/L | 1.22 |
| $\delta^{13}C$ of Methane in the flashed gas (‰ vs. VPDB)[1] | - |

| | |
|---|---|
| TDS (Calculated), mg/L | 216,280 |
| TDS (Gravimetric), mg/L | 222,935 |
| Resistivity, Ohm-cm @ 25 °C | 3.98 |
| Total Alkalinity, mg $CaCO_3$/L | 146 |
| Concentration of carbonate by Titration, mg/L | 0 |
| Concentration of bicarbonate by Titration, mg/L | 178.1 |
| Concentration of Vanadium, mg/L | < 0.1 |
| Concentration of Selenium, mg/L | <0.1 |
| Concentration of Arsenic, mg/L | < 0.1 |
| Concentration of Total Organic Carbon (TOC), mg/L | 1.22 |
| Concentration of Uranium, mg/L | < 0.1 |
| δ13C of Carbon Dioxide in the flashed gas(‰ vs. VPDB) | -8.559 |

[1]The concentration of Methane in the sample was too low to measure the methane isotopes

ICP: Inductively Coupled Plasma IC: Ion Chromatography NT: Not Tested

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# INTERIM REPORT

## ANALYSIS OF THE WATER FLASHED FROM THE SAMPLE LABELED JUNIPER M-1 1.04 SAMPLE DEPTH: 9066.67', PERFORATION INTERVAL: 9165' - 9171' (LYONS FORMATION)

**Best Core Services**
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111 Lake Street
Bakersfield, California 93305

**PROJECT NUMBER**
WTC-23-009603

**COMPILED BY**
Intertek Westport Technology Center

**DATE**
August 14, 2023



**List of Revisions**

| REVISION | DATE | REVISION DETAILS | AUTHOR | ISSUE |
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| 0 | 8/14/2023 | - | Grant Broker | 1 |

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*page*

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Table 1: Analysis of Water Flashed from the Sample Labeled Juniper M-1 1.04, Sample Depth: 9066.67', Perforation Interval: 9165' - 9171' (Lyons Formation) 4

# EXECUTIVE SUMMARY

## Introduction

At the request of Best Core Services, a custom water analysis was conducted on one water sample flashed from the sample labeled Juniper M-1 1.04, Sample Depth: 9066.67', Perforation Interval: 9165' - 9171' (Lyons Formation) (Note: the well was perforated, swabbed, and sampled at 9066.67').

## Experimental Procedures

### Ion Chromatography (IC) of Anions

The concentrations of bromide, chloride, fluoride, iodide, nitrate, nitrite, phosphate, and sulfate in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES)

The concentrations of aluminium, barium, boron, cadmium, calcium, chromium, copper, iron, lead, lithium, magnesium, manganese, nickel, phosphorous, potassium, silicon, sodium, strontium, zinc, arsenic, selenium, vanadium, and uranium in the water sample were determined using Inductively Coupled Plasma Spectroscopy. It should be noted that the sample solution was diluted as required prior to analysis.

### Ion Chromatography (IC) of Organic Acids

The concentrations of acetic acid, butyric acid, formic acid, glycolic acid, propionic acid in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### pH

The pH of the water sample was determined following the procedure given in ASTM D1293.

### Alkalinity

The concentrations of carbonate and bicarbonate in the water sample were determined using a Dionex ICS 3000 Ion Chromatograph. It should be noted that the sample solution was diluted as required prior to analysis.

### Conductivity

The Conductivity/Resistivity of the water sample was determined following the procedure given in ASTM D1125.

### Density

The density of the water sample was determined following the procedure given in ASTM D4052.

### Total Dissolved Solids

The concentration of total dissolved solids in the water sample was determined following the procedure given in ASTM D5907.

### Total and Dissolved Organic Carbon

The concentrations of total and dissolved organic carbon in the water sample were determined following the procedure given in SM 5310C.

## Water Isotope Analysis (Hydrogen and Oxygen)

Hydrogen isotopes were measured by Isotope Ratio Mass Spectrometry (IRMS) on hydrogen gas after equilibration of the water with the hydrogen. Oxygen isotopes were measured on carbon dioxide gas by IRMS after equilibration of the water with the carbon dioxide.

## Water Isotope Analysis (Strontium Isotopes)

The water sample was treated following the protocol outlined in Environmental Science & Technology 2012 46 (6), 3545-3553. A sufficient volume of each sample (typically 1-3 mL) is acidified to a pH of 2 or less, passed through pre-cleaned 45 µm filters, and dried down in pre-cleaned Teflon beakers. The residue is taken up in approximately 1 mL of concentrated HNO3, dried again, then taken into solution in 1mL of 8M HNO3. Approximately 70 µL of this solution is then loaded onto pre-cleaned and conditioned columns containing Eichrom® Sr-Spec resin, and Sr is isolated and collected by standard ion chromatographic techniques similar to the protocol described in Geochemistry, Geophysics, Geosystems, 15, 499-508, using 8M HNO3 to strip interfering cations, followed by MilliQ water to release resin-bound Sr at the appropriate time. Column chemistry has been finely calibrated to maximize the separation of Rb from Sr, thus eliminating nearly all isobaric interference of $^{87}$Rb in the final eluent.

Sr isotopic compositions are determined on a Nu-Plasma II MC-ICP-MS in static mode. $^{87}Sr/^{86}Sr$ ratios are corrected for mass bias using exponential law and $^{86}Sr/^{88}Sr = 0.1194$. $^{87}$Sr is corrected for isobaric Rb by monitoring the intensity of $^{85}$Rb and subtracting the intensity of $^{87}$Rb from the intensity of $^{87}$Sr using $^{87}Rb/^{85}Rb = 0.386$ and a mass bias correction factor determined from $^{86}Sr/^{88}Sr$. All analyses are corrected for isobaric interference of Kr impurities in the Ar gas by using on-peak measured zeros determined on an ultra-high purity 2% HNO . The value determined for NBS 987 and USGS BHVO-2 during the course of the day was 0.710236 ± 0.000013 (n=7) and 0.703428 ± 0.000024 (n=4), respectively.

## Water Isotope Analysis ($\delta^{13}$C (Carbon Isotope Analysis) of Dissolved Inorganic Carbon (DIC))

The $\delta^{13}$C of DIC is determined by injecting up to 1 ml of sample water into a helium flushed 12mL Exetainer® containing 0.1mL of 85% phosphoric acid and a magnetic spin bar. Sample size is determined based on alkalinity, which is measured by titration with 0.1N HCl.
The sample is stirred for a minimum of one hour and then allowed to equilibrate for 24 hours. At time of analysis the sample vials are placed in the GasBench tray. The $CO_2$ generated is flushed out of the vial via a two port needle. Water is removed by two nafion traps, and pure $CO_2$ is separated using a GC column. The $CO_2$/helium mixture then enters the mass spectrometer and is compared against a reference standard a total of six times.

## Water Isotope Analysis ($\delta^{14}C$ (Carbon Isotope Analysis) of Dissolved Inorganic Carbon (DIC))

The Accelerator Mass Spectrometry (AMS) measurement is done on graphite produced by hydrogen reduction of the $CO_2$ sample over a cobalt catalyst. The $CO_2$ is obtained from the combustion of the sample at 800°C under a 100% oxygen atmosphere. The $CO_2$ is first dried with methanol/dry ice then collected in liquid nitrogen for the subsequent graphitization reaction. The identical reaction is performed on reference standards, internal QA samples, and backgrounds to ensure systematic chemistry.

The analytical result ("BP" or "pMC") is obtained by measuring sample $^{14}C/^{13}C$ relative to the $^{14}C/^{13}C$ in Oxalic Acid II (NIST-4990C) in a particle accelerator using SNICS ion source. Quality assurance samples are measured along with the unknowns and reported separately in a "QA report". The radiocarbon dating lab requires results for the QA samples to fall within expectations of the known values prior to accepting and reporting the results for any given sample.

The AMS result is corrected for total fractionation using machine graphite δ13C. The δ13C reported for the sample is obtained by different ways depending upon the sample material. Solid organics are sub-sampled and converted to $CO_2$ with an elemental analyzer (EA). Water and carbonates are acidified in a gas bench to produce $CO_2$. Both the EA and the gas bench are connected directly to an isotope-ratio mass spectrometer (IRMS). The IRMS performs the separation and measurement of the $CO_2$ masses (44, 45, and 46) and calculation of the sample δ13C.

## Gas Isotope Analysis ($\delta^{13}C$ (Carbon Isotope Analysis) of Methane and Carbon Dioxide

Samples were analyzed for carbon isotope composition of methane and carbon dioxide by continuous flow gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) using a Thermo Delta V Plus IRMS outfitted with an Agilent 7890A GC, GC Isolink, and Conflo IV. Results were corrected to known standards and expressed as ppt vs. VPDB.

## Results and Discussion

The results of the custom water analysis are presented in Table 1.

**Table 1: Analysis of Water Flashed from the Sample Labeled Juniper M-1 1.04, Sample Depth: 9066.67', Perforation Interval: 9165' - 9171' (Lyons Formation)**

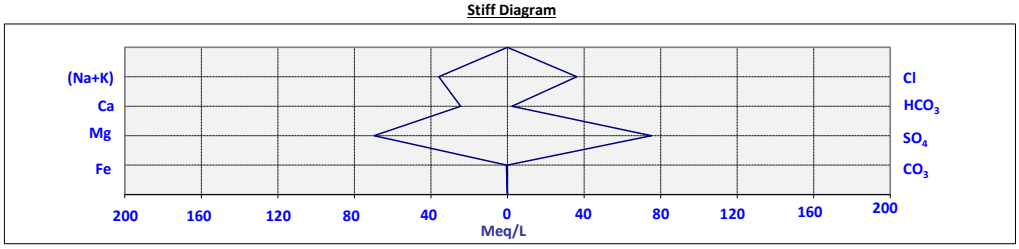
| | Cations | | Test Method | (mg/L) | MW | Valence | Factor | Meq/L |
|---|---|---|---|---|---|---|---|---|
| 1 | Aluminium | $Al^{3+}$ | ICP | <0.1 | 27.0 | 3 | 9.0 | n/a |
| 2 | Ammonium | $NH_4^+$ | ICP | NT | 18.0 | 1 | 18.0 | n/a |
| 3 | Barium | $Ba^{2+}$ | ICP | <0.1 | 89.1 | 2 | 44.6 | n/a |
| 4 | Boron | $B^{3+}$ | ICP | 47.8 | 10.8 | 3 | 3.6 | 13.3 |
| 5 | Cadmium | $Cd^{2+}$ | ICP | <0.1 | 112.4 | 2 | 56.2 | n/a |
| 6 | Calcium | $Ca^{2+}$ | ICP | 490.3 | 40.1 | 2 | 20.0 | 24.5 |
| 7 | Copper | $Cu^{2+}$ | ICP | <0.1 | 63.5 | 2 | 31.8 | n/a |
| 8 | Chromium | $Cr^{3+}$ | ICP | <0.1 | 52.0 | 3 | 17.3 | n/a |
| 9 | Iron (total) | $Fe^{2+}$ | ICP | 17.5 | 55.8 | 2 | 27.9 | 0.6 |
| 10 | Lead | $Pb^{2+}$ | ICP | <0.1 | 207.2 | 2 | 103.6 | n/a |
| 11 | Lithium | $Li^+$ | ICP | 13.6 | 6.9 | 1 | 6.9 | 2.0 |
| 12 | Magnesium | $Mg^{2+}$ | ICP | 847.0 | 24.3 | 2 | 12.2 | 69.7 |
| 13 | Manganese | $Mn^{2+}$ | ICP | 2.0 | 54.9 | 2 | 27.5 | 0.1 |
| 14 | Nickel | $Ni^{2+}$ | ICP | <0.1 | 58.7 | 2 | 29.4 | n/a |
| 15 | Phosphorus | $P^{3+}$ | ICP | <0.1 | 31.0 | 3 | 10.3 | n/a |
| 16 | Potassium | $K^+$ | ICP | 2595.8 | 39.1 | 1 | 39.1 | 66.4 |
| 17 | Silicon | $Si^{4+}$ | ICP | 19.0 | 28.1 | 4 | 7.0 | 2.7 |
| 18 | Sodium | $Na^+$ | ICP | 81038.2 | 23.0 | 1 | 23.0 | 3525.0 |
| 19 | Strontium | $Sr^{2+}$ | ICP | 12.7 | 87.6 | 2 | 43.8 | 0.3 |
| 20 | Zinc | $Zn^{2+}$ | ICP | 4.0 | 65.4 | 2 | 32.7 | 0.1 |

| | Anions | | Test Method | (mg/L) | MW | Valence | Factor | Meq/L |
|---|---|---|---|---|---|---|---|---|
| 1 | Acetate | $CH_3COO^-$ | IC | < 0.5 | 59.0 | 1 | 59.0 | n/a |
| 2 | Bicarbonate | $HCO_3^-$ | IC | 139.8 | 61.0 | 1 | 61.0 | 2.3 |
| 3 | Bromide | $Br^-$ | IC | 48.1 | 79.9 | 1 | 79.9 | 0.6 |
| 4 | Butyrate | $CH3CH_3CH_2CO_2^-$ | IC | < 0.5 | 88.1 | 1 | 88.1 | n/a |
| 5 | Carbonate | $CO_3^{2-}$ | IC | 0.0 | 60.0 | 2 | 30.0 | 0.0 |
| 6 | Chloride | $Cl^-$ | IC | 128496.8 | 35.5 | 1 | 35.5 | 3619.6 |
| 7 | Fluoride | $F^-$ | IC | < 0.1 | 19.0 | 1 | 19.0 | n/a |
| 8 | Formate | $HCOO^-$ | IC | < 0.5 | 45.0 | 1 | 45.0 | n/a |
| 9 | Glycolate | $OHCCOO^-$ | IC | < 0.5 | 76.1 | 1 | 76.1 | n/a |
| 10 | Hydroxide | $OH^-$ | Titration | 0.0 | 17.0 | 1 | 17.0 | 0.0 |
| 11 | Iodide | I- | IC | < 0.5 | 126.9 | 1 | 126.9 | 0.6 |
| 12 | Nitrate | $NO_3^-$ | IC | < 0.5 | 62.0 | 1 | 62.0 | n/a |
| 13 | Nitrite | $NO_2^-$ | IC | 1.5 | 46.0 | 1 | 46.0 | 0.0 |
| 14 | Phosphate | $PO_4^{3-}$ | IC | <0.5 | 95.0 | 3 | 31.7 | n/a |
| 15 | Propionate | $CH_3CH_2CO_2^-$ | IC | < 0.5 | 73.1 | 1 | 73.1 | n/a |
| 16 | Sulphate | $SO_4^{2-}$ | IC | 3609.8 | 96.1 | 2 | 48.0 | 75.2 |

| | |
|---|---|
| **Total Cation Meq's** | **3705** |
| **Ion Balance** | **1.002** |

| | |
|---|---|
| **Total Anion Meq's** | **3698** |

**Stiff Diagram**




| | |
|---|---|
| pH | 6.39 |
| Conductivity, mS/cm @ 25 °C | 252.1 |
| Hardness, ppm | 4,955 |
| Salinity, g/Kg | 226.0 |
| Density (g/cm$^3$ @ 20 °C) | 1.1684 |
| δD H2O (‰ vs VSMOW) | -54.29 |
| δO H2O (‰ vs VSMOW) | -3.78 |
| Strontium Isotopes ($^{87}Sr/^{86}Sr$) | pending |
| $\delta^{13}C$ of DIC (‰ vs VPDB) | pending |
| $\delta^{14}C$ Content of DIC (% modern Carbon) | pending |
| Concentration of Dissolved Organic Carbon (DOC), mg/L | 1.05 |
| $\delta^{13}C$ of Methane in the flashed gas (‰ vs. VPDB)[1] | - |

| | |
|---|---|
| TDS (Calculated), mg/L | 216,280 |
| TDS (Gravimetric), mg/L | 225,898 |
| Resistivity, Ohm-cm @ 25 °C | 3.97 |
| Total Alkalinity, mg $CaCO_3$/L | 148 |
| Concentration of carbonate by Titration, mg/L | 0 |
| Concentration of bicarbonate by Titration, mg/L | 180.6 |
| Concentration of Vanadium, mg/L | < 0.1 |
| Concentration of Selenium, mg/L | <0.1 |
| Concentration of Arsenic, mg/L | < 0.1 |
| Concentration of Total Organic Carbon (TOC), mg/L | 1.05 |
| Concentration of Uranium, mg/L | < 0.1 |
| δ13C of Carbon Dioxide in the flashed gas(‰ vs. VPDB) | -8.817 |

[1]The concentration of Methane in the sample was too low to measure the methane isotopes

ICP: Inductively Coupled Plasma IC: Ion Chromatography NT: Not Tested

# APPENDIX D—FRESHWATER WELL FLUID-SAMPLING LABORATORY ANALYSIS

The groundwater monitoring plan and fluid sampling strategy is outlined in Section 4.3.5 and 4.3.7 and will cover the injection and post-injection monitoring periods. The plan will utilize 3 groundwater monitoring wells per injector within the AoR to characterize the baseline, injection, and post-injection fluid chemistry of freshwater aquifers.

A summary of existing water quality data that was used to characterize freshwater aquifers during site characterization can be found in *Section 2.2.1.*

# APPENDIX E—QUALITY ASSURANCE AND SURVEILLANCE PLAN

The Quality Assurance and Surveillance Plan is attached as a separate document:

## Goal

This Quality Assurance and Surveillance Plan provides confidence that the underground storage project is operating as planned and ensures that the geologic sequestration project is operating as permitted and not endangering Underground Sources of Drinking Water (USDWs). This program was prepared to meet the requirements of Wyoming Department of Environmental Quality (WYDEQ) Water Quality Rules Chapter 24 **§20**.

## Overview

Details for testing and monitoring requirements include: (1) the analysis of injected $CO_2$; (2) periodic testing of the injection well (internal and external mechanical integrity testing); (3) a plan for corrosion monitoring of all components that will be exposed to $CO_2$; (4) a surface leak detection and monitoring plan for surface components of the injection system; (5) and a near-surface/deep-subsurface leak detection plan to detect any movement of $CO_2$ outside of the storage formation. This plan will provide further details about the quality assurance and surveillance procedures that will be implemented in the testing and monitoring program.

## Monitoring and Analysis of Injected $CO_2$

The carbon dioxide stream will be analyzed with sufficient frequency to yield data representative of its chemical and physical characteristics. This analysis aims to evaluate the potential interactions of carbon dioxide and other constituents of the injectate with formation solids, fluids, or any components of the injection system. Testing will be conducted using gas chromatography analysis. This analysis will also test for constituents that include sulfur dioxide, hydrogen sulfide, nitrogen oxides, hydrocarbons, carbon monoxide, methane, water vapor, nitrogen, oxygen, mercury, and arsenic. The gas chromatography equipment will meet American Society for Testing and Materials (ASTM) testing standards.

## Injection Well Testing

The external mechanical integrity of the injection well will be validated using Schlumberger's USI UltraSonic Imager Tool (USIT) or similar technology. This survey will be run before injection begins. Specifications for this technology are provided in Attachment E-1**.**

Internal mechanical integrity will be validated at least once every five years by performing a tubing/casing annular pressure test. The test procedure can be found in Attachment E-2.

## Corrosion Monitoring and Prevention

### Monitoring

A corrosion coupon system will be installed, and the coupons will be deployed using a valved loop through which the injection stream passes. This monitoring method will detect any possible metal loss due to the chemical or electrochemical reactions that may result in loss of mass or thickness or pitting of injection well components. The coupons will be prepared, analyzed, installed, and quality assurance (QA)/quality control (QC) protocols will be implemented using the National Association of Corrosion Engineers (NACE) RP-0775 and ASTM Standards G1 and G4.

### Prevention

Corrosion will be prevented by limiting the amount of moisture content of the injectate and utilizing $CO_2$-resistant materials in all system components that will encounter the $CO_2$. All materials used will be manufactured to American Petroleum Institute (API) 5CT and International Organization for Standardization (ISO) 11960 specifications. The design of cementing materials will follow API 10A. The cement used across the injection zone and upper confining intervals will be designed to resist acid and meet the standards of API 10A (Specification for Cements and Materials for Well Cementing).

Additional methods to control the composition of gas may be employed during the operation of the storage project—including the dehydration systems and application of corrosion inhibitors. In applying these corrective interventions, assistance from expert service providers will be secured. Service providers will use their QA/QC methods and be made available upon request.

## Surface Leak Monitoring

$CO_2$ detectors will be utilized to detect leaks at any surface locations. The detectors will be integrated with the site alarm system, which will continuously monitor for any leaks at the site. The selected $CO_2$ detection monitors will be tested annually to ensure they are correctly calibrated and function as intended. If the devices cannot be calibrated to within the manufacturer's specifications, they will be replaced.

## Near-Surface Monitoring: Groundwater

Near-surface monitoring will consist of groundwater sampling of three shallow wells located on the injector well pads. The three wells will be drilled to approximate depths of 100, 250 and 1,000 ft to allow for fluid sampling across all proposed USDWs.

### Baseline

Baseline sampling is planned as part of the overall groundwater monitoring plan. The baseline sampling period will consist of sufficient samples taken over several months to determine the expected levels of $CO_2$ present and other key compositional parameters present in the groundwater before injection starts.

## Mechanical Integrity

### Pulse Neutron Logs

Pulsed neutron logs will provide information regarding gas saturations in formation and allow for fluid identification behind casing. This technology will validate the absence of fluid migration and verify that the injection of $CO_2$ is contained within the target storage formation. The logs are run on digital slickline through tubing. The specifications of the pulse neutron logging tool are provided in Attachment E-3.

### Ultrasonic Logs

The USIT will be used to assess the internal and external mechanical integrity of the casing. Using ultrasonic pulses, the tool can indicate the quality of the cement bond at the cement/casing interface. This logging tool can detect corrosion, internal and external damage or deformation, and casing thickness data, which will be used for collapse and burst pressure determinations. The USIT scans the full circumference of the casing with a resolution that can detect cement channels down to a thickness of 1.2 inches. The specifications for the ultrasonic log are provided in Attachment E-1.

### Pressure Falloff Testing

Per the requirements of WYDEQ Chapter 24 **§24.17(d)** and **§24.20(b)(vii)**, High Plains will conduct a baseline pressure falloff test before injection and then every five years. The data gathered from the test will be used to measure formation properties. The pressure will be recorded using pre-calibrated tandem gauges and a wellhead pressure gauge.

## Modular Formation Dynamics Test (MDT) Tool

During drilling and completion of the Spirea I-1 well, SLB's MDT tool will be run to gather formation fluid samples and pressure measurements. Fluid samples will be taken from the Lyons, Sundance, Fox Hills and any other permeable formations to assist in evaluating as potential USDWs. MDT pressure measurements will be recorded in the same intervals as the fluid sampling locations. Additionally, MDT pressure measurements will be collected from the upper and lower confining zones. Detailed specifications of the tool are included in Attachment E-4.

## Direct Reservoir Monitoring

The storage reservoir will be monitored during injection well operations using distributed temperature sensing (DTS) and distributed acoustic sensing (DAS) sensors run on fiber optic cable behind the casing in the injection wells. The gauges will continuously monitor and provide data recorded in real time. The specifications for these gauges and the fiber optic system are supplied in Attachments E-5 and E-6.

**Indirect Monitoring Methods**

The extent of the $CO_2$ plume will be monitored using time-lapse 2D seismic surveys. High Plains will establish a baseline view of the injection interval and then subsequent surveys will be acquired during injection for use in simulation model updates. Additionally, post injection, subsequent surveys will be acquired to confirm the plume stabilization. These data and interpretations will be compared to those from the baseline surveys to determine the extent of the $CO_2$ plume. The acquired data will also be used to refine the plume model and update the AoR. The 2D surveys acquired once injection begins will be designed to cover the expected plume area in a spoke-like fashion, as shown in Figure 4.4.

## Attachments: Specifications for Specialized Monitoring Tools

### *E-1: USI UltraSonic Imager Tool*

***E-1: USI UltraSonic Imager Tool***

# USI UltraSonic Imager Tool

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The USI* UltraSonic Imager tool (USIT) uses a single transducer mounted on an Ultrasonic Rotating Sub (USRS) on the bottom of the tool. The transmitter emits ultrasonic pulses between 200 and 700 kHz and measures the received ultrasonic waveforms reflected from the internal and external casing interfaces. The rate of decay of the waveforms received indicates the quality of the cement bond at the cement/casing interface, and the resonant frequency of the casing provides the casing wall thickness required for pipe inspection. Because the transducer is mounted on the rotating sub, the entire circumference of the casing is scanned. This 360° data coverage enables the evaluation of the quality of the cement bond as well as the determination of the internal and external casing condition. The very high angular and vertical resolutions can detect channels as narrow as 1.2 in. [3.05 cm]. Cement bond, thickness, internal and external radii, and self-explanatory maps are generated in real time at the wellsite.

**Applications**

- Cement evaluation
- Casing inspection
  - Corrosion detection and monitoring
  - Detection of internal and external damage or deformation
  - Casing thickness analysis for collapse and burst pressure calculations

**Measurement Specifications**

| | USIT |
|---|---|
| Output | Acoustic impedance, cement bonding to casing, internal radius, casing thickness |
| Logging speed | 1,800 ft/hr [549 m/h] |
| Range of measurement | Acoustic impedance: 0 to 10 MRayl [0 to 10 MPa.s/m] |
| Vertical resolution | Standard: 6 in. [15.24 cm] |
| Accuracy | Less than 3.3 MRayl: ±0.5 MRayl |
| Depth of investigation | Casing-to-cement interface |
| Mud type or weight limitations† | Water-base mud: Up to 15.9 lbm/gal<br>Oil-base mud: Up to 11.2 lbm/gal |
| Combinability | Bottom-only tool, combinable with most tools |
| Special applications | Identification and orientation of narrow channels |

†Exact value depends on the type of mud system and casing size.

**Mechanical Specifications**

| | USIT |
|---|---|
| Temperature rating | 350°F [177°C] |
| Pressure rating | 20,000 psi [138 MPa] |
| Casing size—min. | 4½ in. [11.43 cm] |
| Casing size—max. | 13⅜ in. [33.97 cm] |
| Outer diameter† | 3.375 in. [8.57 cm] |
| Length† | 19.75 ft [6.02 m] |
| Weight† | 333 lbm [151 kg] |
| Tension | 40,000 lbf [177,930 N] |
| Compression | 4,000 lbf [17,790 N] |

† Excluding the rotating sub

**USIT Rotating Sub Mechanical Specifications**

| | USRS-AB | USRS-A | USRS-B | USRS-C | USRS-D |
|---|---|---|---|---|---|
| Outer diameter | 3.41 in. [8.66 cm] | 3.58 in. [9.09 cm] | 4.625 in. [11.75 cm] | 6.625 in. [16.83 cm] | 8.625 in. [21.91 cm] |
| Length | 9.8 in. [24.89 cm] | 9.92 in. [25.20 cm] | 9.8 in. [24.89 cm] | 8.3 in. [21.08 cm] | 8.3 in. [21.08 cm] |
| Weight | 7.7 lbm [3.5 kg] | 7.7 lbm [3.5 kg] | 10.6 lbm [4.8 Kg] | 15.0 lbm [6.8 kg] | 18.3 lbm [8.3 kg] |

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### *E-2: Mechanical Integrity Test Procedures*

1. Notify the Administrator in writing at least 30 days in advance of the test.
2. Fill the tubing-casing annulus with an approved fluid at least 24 hours before the planned test.
3. Read the tubing pressure and record.
4. Read the pressure on the tubing-casing annulus and record. If there is pressure on the annulus, bleed off before testing.
5. Connect the pressure source to the tubing-casing annulus and begin applying pressure until the desired test value has been reached.
6. Close the valve and begin recording the pressure for the test duration.
7. Record the tubing and annulus pressure value every five minutes in addition to chart recording.
8. At the end of the test, record the final tubing pressure.
9. Bleed pressure from the casing annulus.
10. A loss of test pressure greater than 10% during the minimum 30 minutes will indicate a potential lack of mechanical integrity and will be further reviewed for mitigation needs.
11. Submit the report to the Administrator within 30 days.

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# Digital Pulsed Neutron

## LIVE PL digital slickline production logging services

### APPLICATIONS

- Locate oil, water, and gas contacts
- Identify known formations in development wells
- Conduct time-lapse logging of reservoir fluid interfaces
- Guide perforating by identifying gas contacts
- Evaluate gravel-pack placement
- Correlate from well to well

### BENEFITS

- Leverage the efficiency and simplicity of slickline operations with the accurate depth control, digital capabilities, and real-time measurement quality of wireline-conveyed services
- Easily conduct operations with a short tool where rig-up height is constrained or space is limited
- Avoid the typical memory limitations of slickline logging with a high-performance lithium ion battery providing up to 15 hours of continuous operation
- Improve operational efficiency with tool combinability and multipurpose deployments
- Reduce risk in wax or debris accumulations by running with D-Jar* digital downhole adjustable jar

### FEATURES

- Full compatibility with LIVE* digital slickline services
- Short, 1 11/16-in-OD tool for through-tubing conveyance and negotiating restrictions
- Deployment on 0.108- or 0.125-in digital slickline
- Sigma, apparent porosity, and gas indicator measurements
- Sourceless pulsed neutron generator
- Accurate real-time onsite depth control
- Logging speed up to 1,800 ft/h
- No memory limitations

*Mark of Schlumberger

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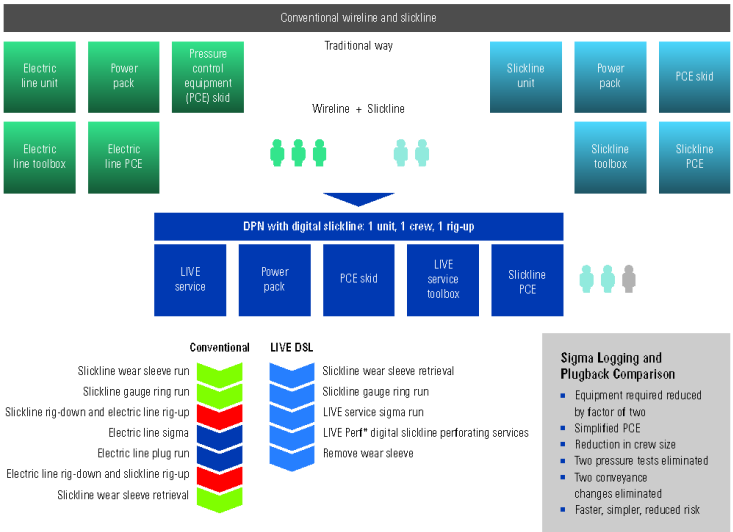
As the latest addition to LIVE PL* digital slickline production logging services, digital pulsed neutron (DPN) service provides crucial information, such as fluid contact monitoring and fluid identification behind casing, to inform wellsite decision making for optimizing reservoir management and production in mature fields.

DPN pairs the field-proven Schlumberger small-diameter high-output pulsed neutron generator (PNG) with dual scintillation gamma ray detectors to provide real-time sigma measurement in mixed-salinity cased hole environments. Dual neutron burst with adaptive timing is performed to ensure the measurement's insensitivity to borehole conditions and eliminate the need for environmental correction. Measurement precision is further honed by using the available job planner.

| Measurement Specifications | Digital Pulsed Neutron |
|---|---|
| Output | Sigma, apparent porosity, gas indicator |
| Logging speed | 1,800 ft/h [549 m/h] |
| Range of measurement | 0 to 60 cu |
| Vertical resolution | 2.5 ft [0.76 m] |
| Precision | <±2% cu |
| Borehole fluid or formation water salinity | >50,000 ppm |
| **Mechanical Specifications** | **Digital Pulsed Neutron** |
| Temperature rating | 302 degF [150 degC] |
| Pressure rating | 15,000 psi [103 MPa] |
| Casing size—min. | 4½ in |
| Casing size—max. | 9⅝ in |
| Outside diameter | 1.72 in [4.37 cm] |
| Weight | 37 lbm [17 kg] |




**Sigma Logging and Plugback Comparison**

- Equipment required reduced by factor of two
- Simplified PCE
- Reduction in crew size
- Two pressure tests eliminated
- Two conveyance changes eliminated
- Faster, simpler, reduced risk

*The efficiency and simplicity of using DPN service on digital slickline with only one unit, one crew, and one rig-up save significant operational time over intervention operations that switch from slickline to electric wireline line for logging and back to slickline.*

slb.com/LIVE

***E-4: Modular Formation Dynamic Tester (MDT)***

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# MDT Modular Formation Dynamics Tester





Quality fluid samples and highly accurate reservoir pressures

### Applications

- Formation pressure measurement and fluid contact identification
- Formation fluid sampling
- Permeability measurement
- Permeability anisotropy measurement
- Mini-drillstem test (DST) and productivity assessment
- In-situ stress and minifrac testing

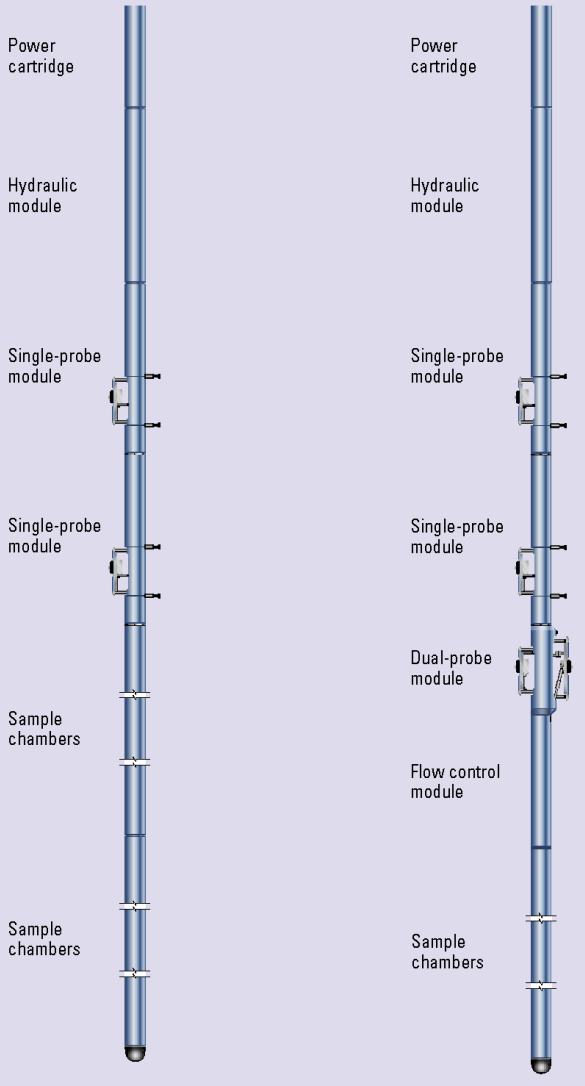
### Benefits

- Testing and sampling in low permeability, laminated, fractured, unconsolidated and heterogeneous formations
- Fast, repeatable pressure measurements
- Faster tests in low permeability—reduced seal losses and probe plugging
- Pressure, volume and temperature (PVT) formation fluid samples
- Downhole fluid differentiation
- Real-time fluid gradients, permeability and contamination assessment

### Features

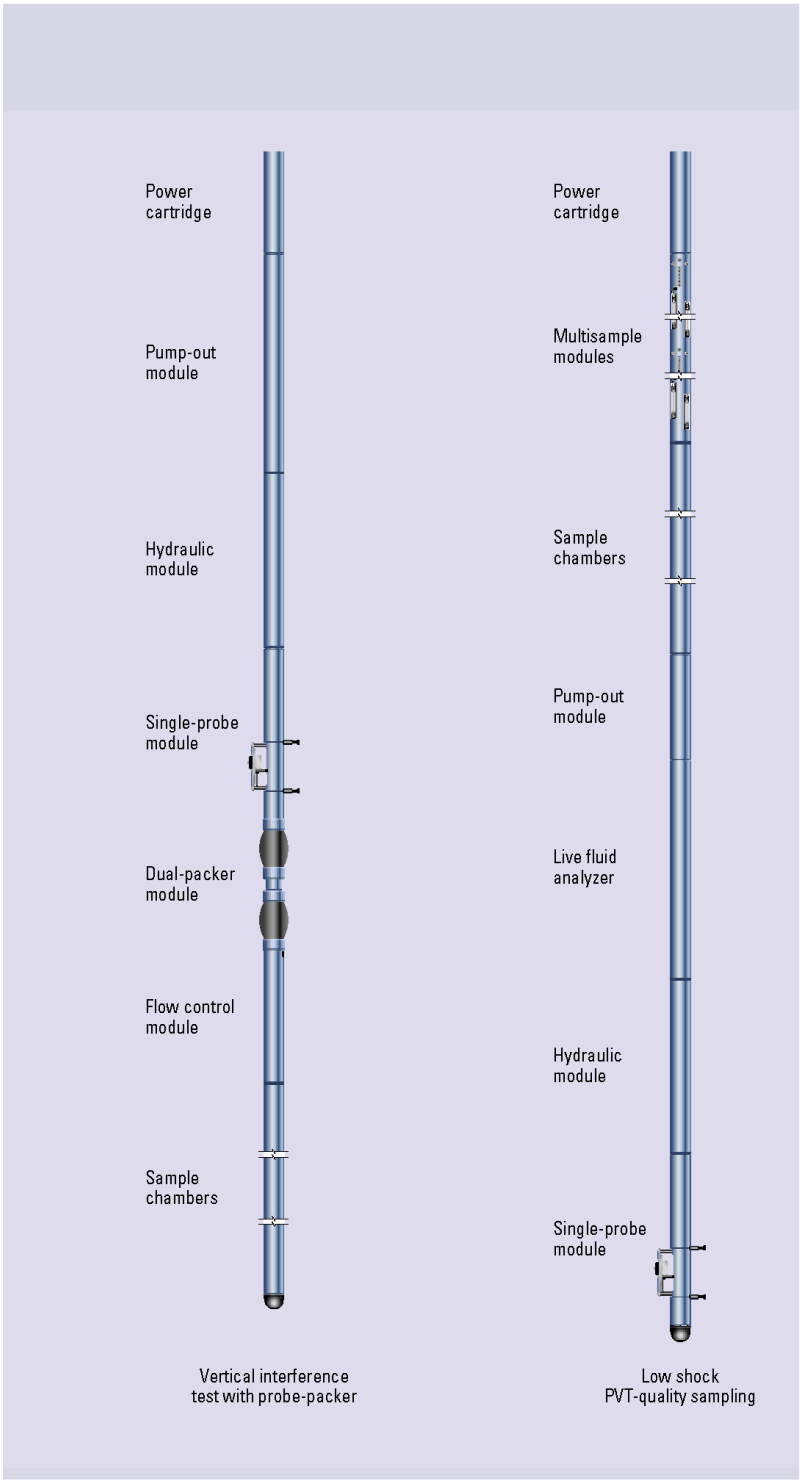
- Modular, custom-design capability
- Multiple samples in one trip
- Multiprobe and inflatable dual packer module options
- Efficient integration with other tools
- Accurate pressure measurements using a CQG* Crystal Quartz Gauge
- Programmable pretest pressure, rate and volume
- Filtrate pumpout prior to sampling
- Fluid resistivity and temperature measurements at the probe
- Quantatative sample contamination measurement with optical spectroscopy techniques
- Low-shock and single-phase sampling
- Field-proven database for accurate pumpout time

*The MDT tool can be customized and efficiently assembled on-site to meet exact requirements depending on the needs of a particular well evaluation.*




Basic MDT configuration for pressure, permeability and sampling

Multi-probe vertical interference testing




### Real-time measurements

The Schlumberger MDT* Modular Formation Dynamics Tester tool provides fast and accurate pressure measurements and high-quality fluid sampling. It can also measure permeability anisotropy. In a single trip, the MDT tool is able to acquire most of the data requirements needed for accurate and timely decision making.

### Flexibility

The key to this remarkable tool is an innovative, modular design that lets you customize the tool for the required applications. MDT modules combine to meet the exact needs and goals of the data acquisition program. This designed flexibility makes the tool compatible with almost all Schlumberger measurement technologies and allows the MDT tool to evolve as new measurement techniques, technologies and options evolve.

### Quick, accurate pressure and permeability measurements

Reservoir pressure measurements using a wireline tester require inserting the probe into the reservoir and withdrawing a small amount of fluid. Since the pressure gauge is exposed to many temperature and pressure changes, these measurements require accurate gauges with high resolution that can dependably react to the dynamic conditions.

The MDT tool uses highly accurate gauges with best-in-class resolution, repeatability and dynamic response for pressure measurements. These pressure gauges exhibit excellent response with no compromise in accuracy or resolution. Precise flowline control during testing and sampling ensures monophasic flow. These innovative features provide the most efficient and accurate permeability determination available.

| MDT Specifications | |
|---|---|
| Single-probe configuration | |
| OD | 4.75 in. [120.6 mm] |
| Min hole size | 5⅞ in. [149. 2 mm][†] |
| Max without kits | 14.25 in. [361.5 mm] |
| Max with kits | 24 in. [610 mm] |
| Pressure rating | 25,000 psi [17,235 kPa][‡] |
| Max temperature rating | 400°F [205°C][§] |
| Multiprobe tool configuration | |
| OD | 6.00 in. [152.4 mm] |
| Min hole size | 7.62 in. [193.6 mm] |
| Max without kit | 13.75 in. [336.5 mm] |
| Max with kit | 15.00 in. [381.00 mm] |
| Max pressure rating | 25,000 psi [17,235 kPa] |
| Max temperature rating | 400°F [205°C] |
| Dual-packer configuration | |
| OD | 5.00 to 10.00 in. [127.0 to 254 mm][††] |
| Min hole size | 5⅞ in. [149.2 mm][††] |
| Max hole size | 14.75 in. [374.6 mm][††] |
| Pressure rating | 25,000 psi [17,235 kPa] |
| Max temperature rating | 325°F [163°C][††] |
| LFA module | |
| OD | 4.75 in. [120.6 mm] |
| Length | 5.83 ft [1.7 m] |
| Weight | 161 lbm [73 kg] |
| Range | 0 to 5 optical density |
| Accuracy | 0.01 optical density |
| Pressure rating | 25,000 psi [17,236 kPa] |
| Temperature rating | 350°F [176°C] |
| **Pressure gauge specifications** | |
| Strain gauge | |
| Range | 0 to 25,000 psi [0 to 17,236 kPa][‡‡] |
| Accuracy | 0.10% full scale |
| Repeatability | 0.06% full scale |
| Resolution | 0.1 psi [0.689 kPa] |
| Temperature rating | 400°F [205°C][‡‡] |
| CQG gauge | |
| Range | 0 to 25,000 psi[‡‡] |
| Accuracy | 2.0 psi [13.8 kPa]+ 0.01% of reading |
| Repeatability | < 1.0 psi |
| Resolution | 0.01 psi |
| Temperature rating | 400°F [205°C][‡‡] |

[†] If wellbore conditions are favorable, the tool can be run on TLC in holes with an ID as small as 5½ in. [14 cm].

[‡] 25,000 psi [172.5 mPa] for the high pressure MDT and 20,000 psi [138 mPa] for the normal MDT tool

[§] 350°F [175°C] with some CQG types

[††] Functional rating based on the actual packer installed and type of mud used.

[‡‡] Actual pressure/temperature combination will depend on specific type of gauge. For the CQG, HCQG-A is rated 175°C/25,000 psi, HCQG-B/D 200°C/18,000 psi or 180°C/20,000 psi and CQG-C/G 175°C/15,000 psi.

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## *E-5: Fiber Optic Cable Specifications*

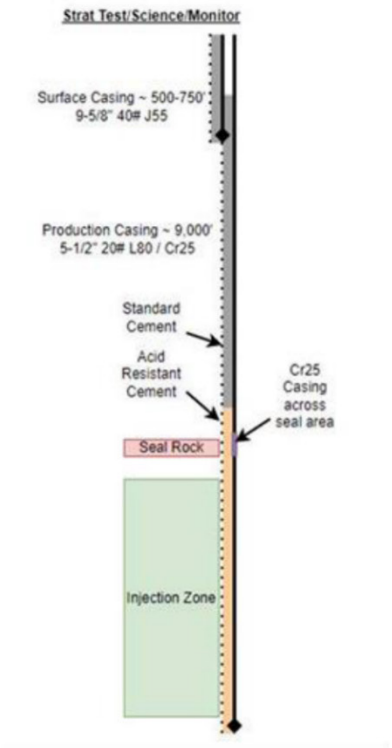



Figure 2: Well design provided.

# 2 Permanent Hardware

## 2.1 Downhole Cable

The fiber optic downhole deployment provides temperature, strain, and acoustic data measurements at high spatial and temporal resolutions with full wellbore coverage. The data are used for reservoir characterization based on reflection and refraction seismic, $CO_2$ plume detection with time-lapse VSP, detection and location of microseismic events, and well integrity and leak detection. Applications can be extended to flow assurance and injectivity profile.

Silixa can provide downhole fiber optic cables with or without Silixa's engineered Constellation optical fiber. The standard cable is designed with two multimode fibers, and three singlemode fibers all in a ¼" O.D. A825 tube construction. Optionally, but highly recommended, one of the singlemode fibers can be substituted for one Silixa's engineered Constellation fiber for improved seismic data acquisition.

The cable is to be permanently installed & attached to the casing using cross-coupling clamps that both protect and secure the cable in place. Mid-joint clamps with extra mass are installed at intervals within the planned perforation zone. These clamps are used to locate the cable position around the tubing prior to the perforation process.

On the surface, the cable will go through the casing hanger and out of the wellhead to a surface enclosure. The enclosure is used to host and protect the optical splices connecting the downhole cable to the surface cable, which is routed to a data acquisition trailer.

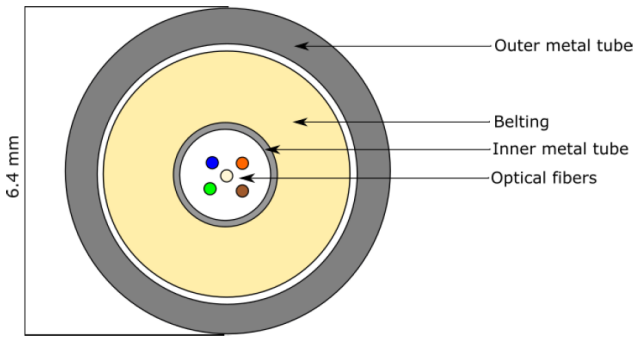



Figure 3: Standard downhole steel tube cable.

The proposed cable design provides multiple layers of hydrogen protection. The optical fibers are "pure core" silica with an additional carbon coating layer. Also, the fibers sit in hydrogen scavenging gel within the inner metal tube.

| Parameter | Specification |
|---|---|
| **Outer tube diameter** | 6.35 mm (0.250") |
| **Outer tube material** | Inconel 825 |
| **Outer tube wall thickness** | 0.889 mm (0.035") |
| **Belting** | Polypropylene |
| **Inner tube diameter** | 2.8 mm |
| **Inner tube material** | Stainless Steel 304L |
| **Number of Multimode fibers** | 2 |
| **Number of single mode fibers** | 2 or 3 |
| **Number of constellation fibers** | 1 or 0 |
| **Temperature rating** | 150 °C |
| **Static bend radius** | 159 mm |
| **Dynamic bend radius** | 635 mm |
| **Approximate Weight** | 147 kg/km |

Table 2: Fiber optic cable specification.

### 2.1.1 Constellation fiber

The scattering properties of optical fiber can be engineered to deliver better DAS performance. A Signal to Noise Ratio improvement of 20 dB can be achieved, along with a wider dynamic range, using engineered fiber with precisely uniform scattering centers. This approach differs from a simple increase in irregular backscattering intensity.

DAS performance is largely governed by how much light can be usefully collected from the optical fiber. In general, we require low loss fiber for long range sensing, but higher scattering fiber to generate more light. These two apparently contradictory requirements can be balanced by engineering bright scatter centers in the fiber, without introducing significant excess loss for the forward propagating light.

The results from VSP surveys demonstrate that DAS with Constellation fiber has the potential to provide similar, or even superior, quality data sets as from conventional geophones. An important aspect is that, due to the higher spatial sampling, DAS data has the capability to provide more detailed velocity information compared to geophones.

## 2.2 Bottom Hole Assembly Specifications

An Incoloy A825 Silixa high pressure 1" OD bottom hole assembly (BHA) seals the end of the cable and houses optical fiber turnarounds (Figure 4). The BHA is attached to the casing with a custom designed steel protector and clamp. Protector clamp schematics and running OD are presented in Figure 5 and Figure 6.

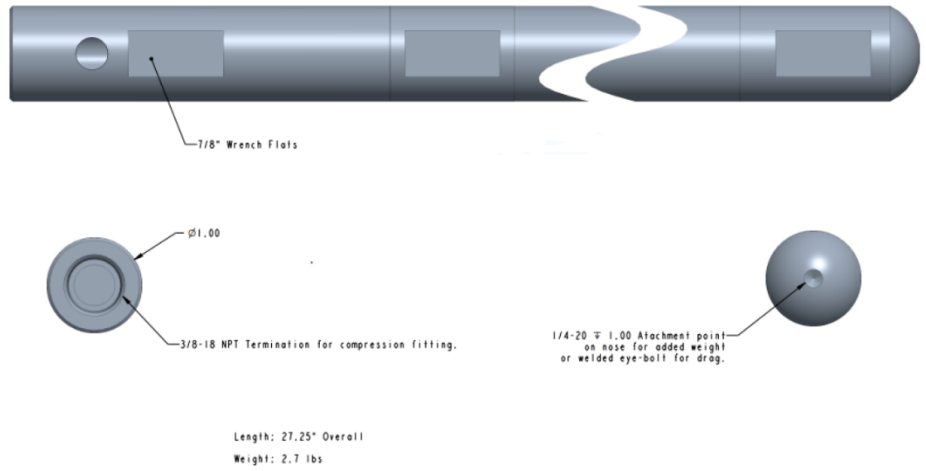



Figure 4: Silixa's high-pressure bottom hole assembly (BHA).

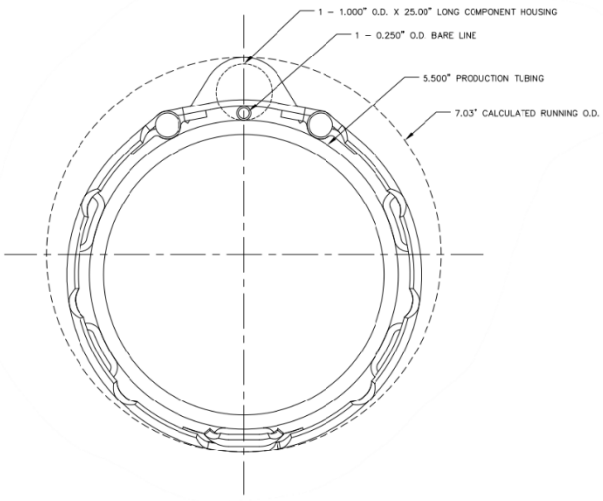



Figure 5: Plan view of BHA clamp.

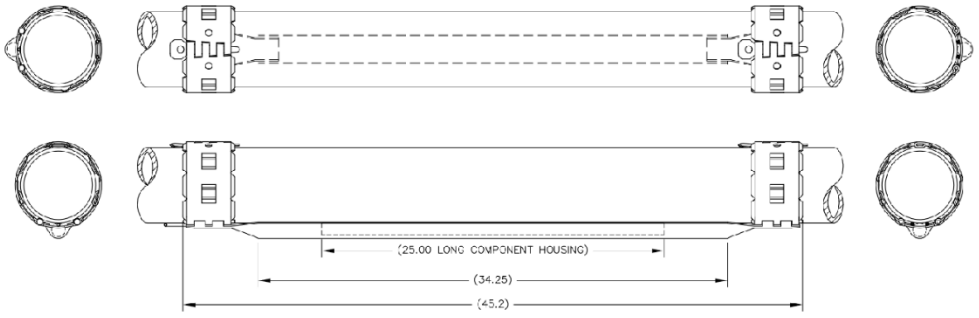



Figure 6: Side view of BHA clamp.

## 2.3 Mini-saddle Clamp Specifications

If repair of the fiber optic cable is required, the optical fibers would be spliced together inside a custom Silixa mini-saddle housing. The mini-saddle housing is protected from abrasion in the wellbore with a custom steel mid-joint clamp. Schematics and running OD are presented in Figure 7 and Figure 8.

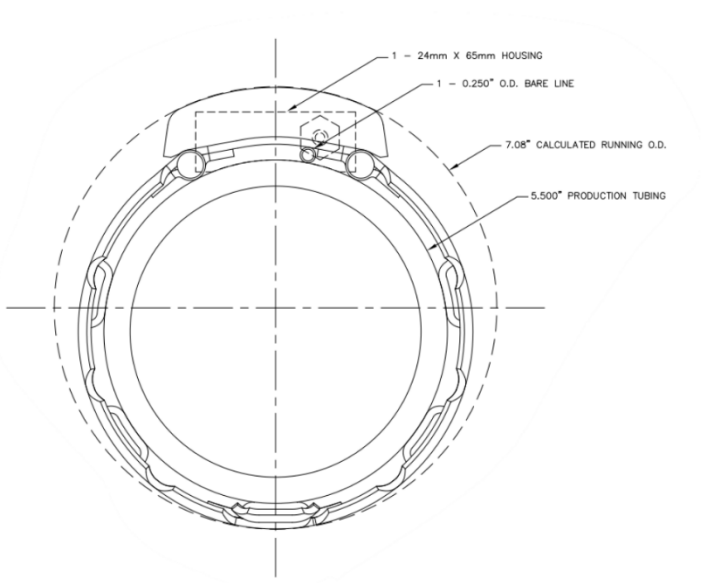



Figure 7: Plan view of mini saddle protector clamp.

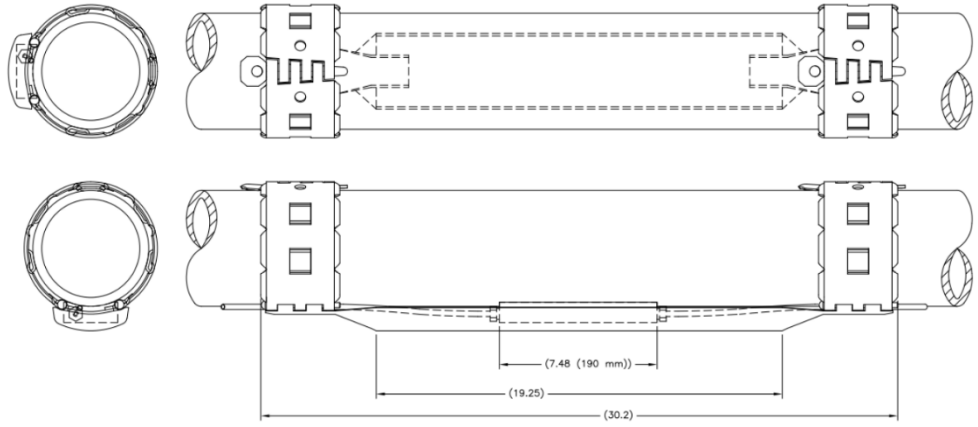



Figure 8: Side view of mini saddle protector clamp.

## 2.1 Wellhead fittings

Fittings and autoclave for the hanger plate and wellhead exit ports are provided based on the wellhead design. A typical fitting is a Swagelok, Male Connector, Bored Through, ¼" Swage x ¼" Male NPT (**Error! Reference source not found.**). An example of the 1" autoclave is the Parker Autoclave Male/Female Adapter, 1 In MP Male X 1/4 In NPT Female, 316SS.

## 2.2 Surface Enclosure

A 24 in x 20 in x 8 in NEMA 4 rated stainless steel surface enclosure is typically used for terminating the downhole cable to a surface cable. The surface cable carries the signal to the instrumentation. This

enclosure can be installed near the wellhead, and the surface cable routed to the data acquisition trailer/room.

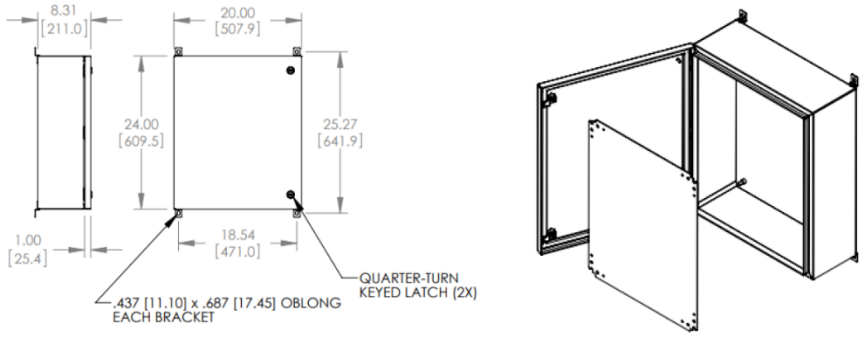



Figure 9: Surface enclosure to host surface fiber optic cable and connectors.

## 2.3 Surface Cable

A surface cable is used to provide connectivity between the downhole cable from the wellhead and the instrumentation location. It is preferable to use a cable of this type as it allows greater flexibility in cable routing and ease of installation.

Tactical tight buffered cables are ideal for such installations. They can survive extreme environmental conditions and are highly resistant to damage caused by repeated impacts crushing forces, abrasion, and extreme temperatures (-55°C to +85°C).

## *E-6: DAS/DTS/DSS Specifications*



Figure 17: 19" Acquisition System Cabinet Rack

All base scope wells and optional wells can be serviced from the same 2 distributed fiber optic acquisition units. Given the limited bandwidth (typically 4G communication) between the wellsite and operator facilities, the proposed solution incorporates local processing and storage. This will allow remote configuration and relatively frequent DTS data transfer as well as local storage of DAS data for selected key time periods which can be collected manually at a later date.

performance, with single-ended (BOTDR) measurement strain resolution of less than 0.5 microstrain, spatial resolution of 60 cm, sampling as fast as 10 Hz, and range capability greater than 50 km.

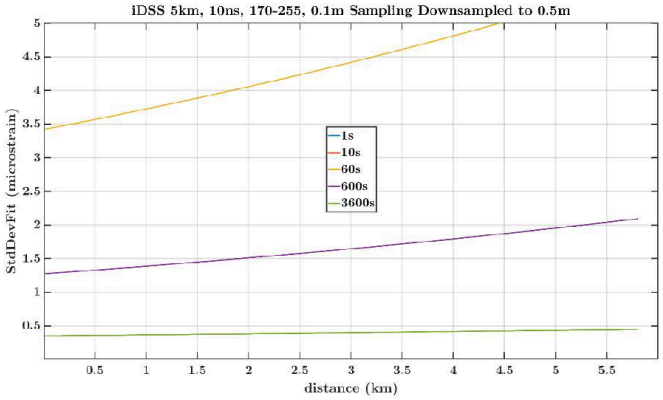



Figure 16: Strain resolution over distance for a 10 ns pulse over 5 km.

| Technical Specification | |
|---|---|
| Range | >50 km |
| Finest Spatial Sampling | 10 cm |
| Finest Spatial Resolution | 60 cm |
| Minimum Measurement Time | 0.1 sec (10 Hz) |
| Finest Strain Resolution | <1 microstrain |
| Mode of Operation | BOTDR |
| Operating Temperature | +5 °C to +40 °C |
| Fiber Compatibility | Standard singlemode optical fiber (9/125), MMF also compatible |
| Calibration | Self-calibrated or ULTIMA temperature compensated |
| Data Interface | 2 x Gb ethernet ports, 2 x SFP+ ports |

Table 4: iDSS technical specifications

## 3.7 Equipment Cabinet

### 3.7.1 Wellsite Local Equipment Room Cabinet

Silixa have included in our offer a 19" rack to be placed in a centralized position, so that the interrogator(s) can be optimized and shared across multiple wells. Silixa has installed similar 19" rack units at both onshore and offshore facilities. Within the cabinet, space can be allocated for power management, fiber management, interrogators, Edge Processing Unit and data storage. A generic example of a cabinet solution is shown in Figure 17.

| Technical Specification | |
|---|---|
| Range | 10 km |
| Spatial Sampling | 25 cm and 50 cm |
| Spatial Resolution | 0.6 m |
| Temporal Resolution | 5 s |
| Accuracy | +/- 0.5°C |
| Operating Temperature | -5 °C to +50 °C |
| Output | Temperature, stokes, antistokes in XML data format |
| Fiber Compatibility | Standard multimode optical fiber (50/125), OM3, OM4 |
| Number of measuring channels | 4 or 8 channels |
| Calibration | Self-calibrated |
| Interface | 2 x Ethernet Ports |

Table 3: DTS technical specifications.

From previous $CO_2$ injection project experience Silixa recognize the importance of a high performance DTS instrument. Casing leaks or migration through annular or caprock pathways can lead to subtle temperature variations. Detecting integrity concerns early allows for rapid investigation and mitigation efforts to be undertaken.

Where $CO_2$ capture is a temporally variant, commingled stream from emitters of diverse industries the differing impurities, although small, will have a significant and dynamic impact on the $CO_2$ phase behavior. To fully understand and manage the $CO_2$ phase behavior in the wellbore accurate and high-resolution temperature measurements will be important.

## 3.6 Distributed Strain Sensor (iDSS™)

Intelligent distributed strain sensor (iDSS™), Silixa's latest cutting-edge innovation, is a versatile fiber optic sensing system that measures absolute static strain along a single-mode or multimode fiber optic cable down to the micro-strain resolution level.



Figure 15: Silixa iDSS interrogator

The interrogator acquires a complete strain profile with every laser shot, meaning low noise strain data can be collected with sub-second averaging times. This transformative performance is achieved by using a high-precision interferometric optical architecture, built upon Silixa's class-leading Carina® Sensing System, the precision-engineered distributed acoustic sensor. This step-change in performance is most acute in long term monitoring applications where temperature variations along the length of the fiber can vary with time, and/or where the exact point of strain build upon an asset is not known ahead of time, when selecting the best placement of sensing technology. The iDSS provides class leading resolution

## 3.5 Distributed Temperature Sensor (ULTIMA™)

The ULTIMA DTS range is the world's highest performing family of Distributed Temperature Sensors. The ULTIMA family offers the finest temperature and spatial resolutions, from 0.01°C and 35cm. It is a standalone unit with an on-board PC and user-friendly software interface. The ULTIMA is available with either 4 or 8 optical channels. The units are optimized for spatial and temperature resolution for the following ranges: 2, 5, 10, 20 and 35km. The system can be configured to produce both single-ended and double-ended measurements. The minimum measurement time is 1 second.



Figure 13 : The Silixa ULTIMA DTS interrogator.

There are many proprietary technical advances in the ULTIMA which enable it to leapfrog the performance of existing DTS systems. The key breakthrough is in maintaining a fine temperature resolution and spatial resolution while allowing short measurement times.

Apart from the best-in-class performance, the new ULTIMA DTS features low power consumption with a peak power usage of 60W and a fanless operation that makes it more resistant to adverse environmental conditions.

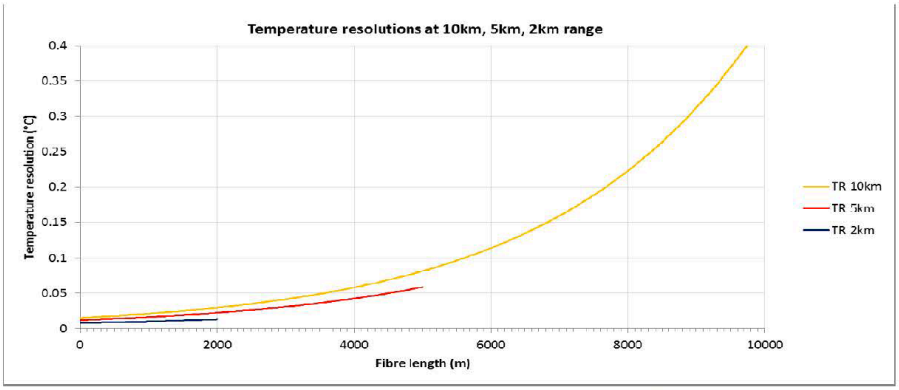



Figure 14: DTS Temperature resolution comparison at three distance settings 0.25 m sampling and 600 s acquisition.

## 6.4 Surface Enclosure

A 24 in x 20 in x 8 in NEMA 4 rated stainless steel surface enclosure is typically used for terminating the downhole cable to a surface cable for sensing interrogator interconnection.

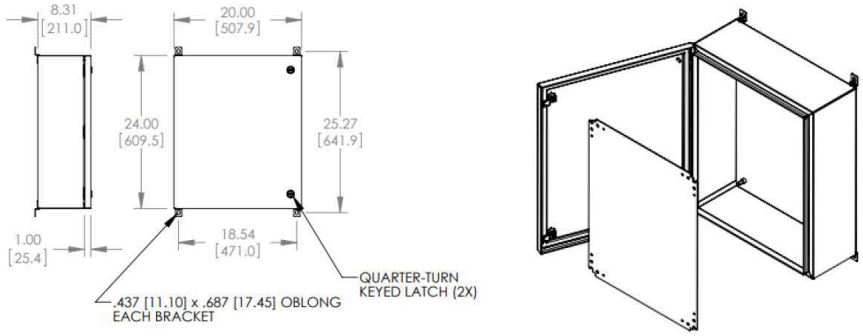



Figure 42. Surface enclosure to host surface fiber optic cable and connectors.

## 6.5 Surface Cable

Silixa proposes a surface cable similar to the below.

Tactical Tight Buffered Cables are ideal for use in installations where extreme environmental conditions are present. Designed to be deployed and retrieved in the field, these surface cables are highly resistant to damage caused by repeated impacts crushing forces, abrasion and extreme temperatures.

They are available with a variety of fibers types & fiber counts and are designed for operational temperatures -55°C to +85°C.



Figure 43: Tight Buffered Tactical Surface Cable

## 6.3 Mini-saddle Clamp Specifications

If repair of the fiber optic cable is required, cables would be spliced together inside a custom Silixa mini-saddle housing. The mini-saddle housing is protected from abrasion in the wellbore with a custom mini-saddle casing clamp. Schematics are presented in Figure 40 and Figure 41.

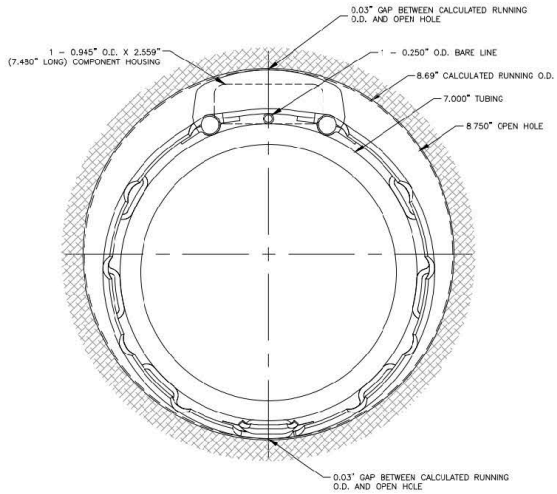



Figure 40: Plan view of mini saddle protector clamp.

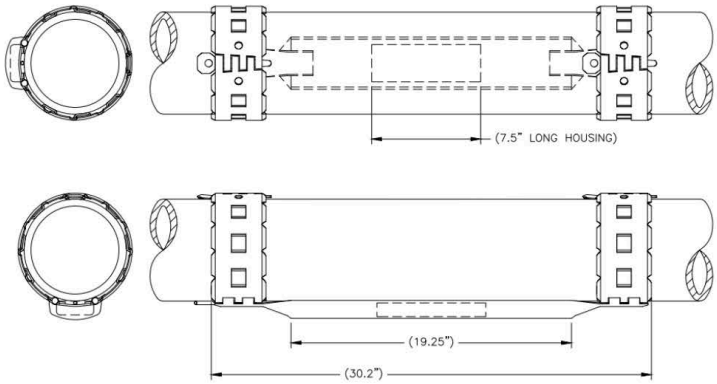



Figure 41: Side view of mini saddle protector clamp.

Figure 37. Silixa's high-pressure bottom hole assembly (BHA).

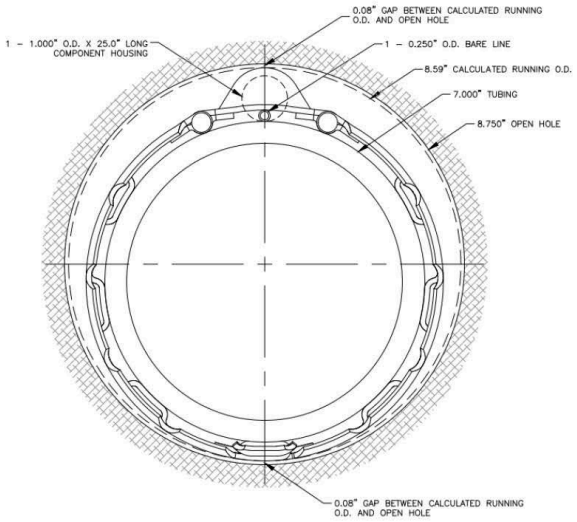



Figure 38: Plan view of BHA clamp.

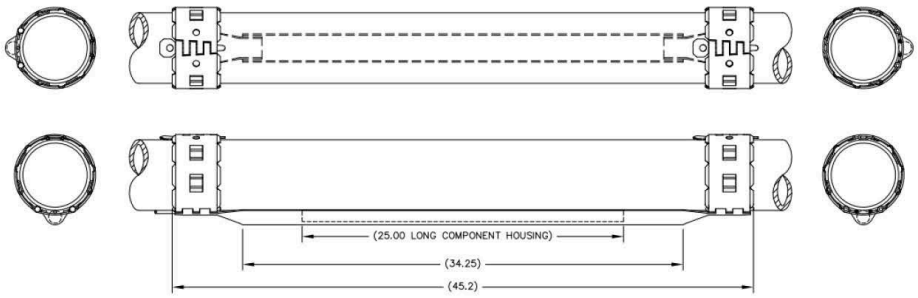



Figure 39: Side view of BHA clamp.

# 6 Downhole and Surface Cable and Completions

## 6.1 Permanent Downhole Cable

For this application Silixa proposes to supply fiber optic cable and installation services with 2 multimode, 2 single-mode, and 1 Silixa Constellation fibers.

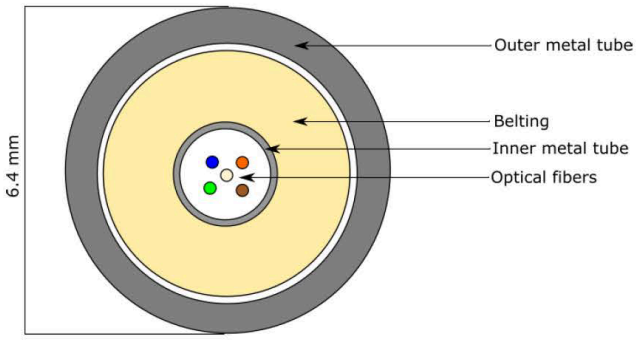
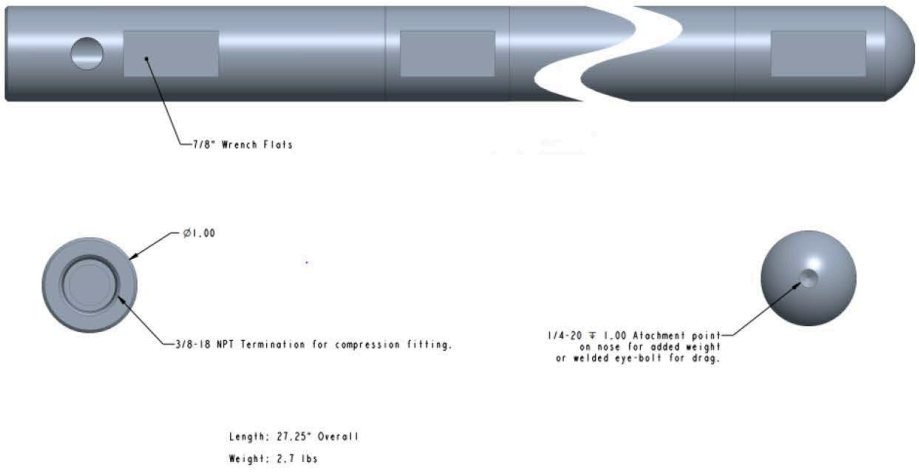



Figure 36: Downhole steel tube cable

## 6.2 Bottom Hole Assembly Specifications

An Incoloy A825 Silixa high pressure 1" OD bottom hole assembly (BHA) seals the end of the cable and house optical fiber turnarounds (Figure 37). The BHA is attached to the casing with a custom designed protector and clamps. Example of the protector clamp schematics are presented in Figure 38 and Figure 39.



Silixa has scheduling software for automatic control of the switch sequence. The software controls the full switching sequence, which includes:

1. Power down interrogator laser to avoid burning optical contacts during switching
2. Move switch position from current to new well output
3. Change configuration file on the DAS interrogator to account for the new well optical path
4. Power up interrogator laser

## 5.6 NTP Server

Silixa proposes to include a master clock / time server with GPS synchronized clock source into the cabinet to provide a highly accurate and extremely high performing networked time server that all the instrumentation can synchronized with.

Key Features

- 1U rackmount
- True Stratum 1 NTP Compatible Master Clock / Time Server.
- Can serve tens of thousands of clients.
- Supports NTP/SNTP
- Front OLED Display for time display and configuration

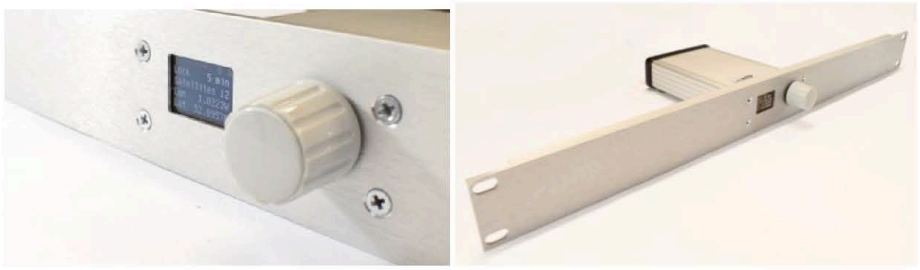


Figure 34: NTP Server

## 5.7 Optical Switch: 1 input, 8 outputs

An optical switch is required to allow one DAS unit to be connected to multiple wells if the wells are not daisy chained in configuration. The switch has a single fiber between the switch and DAS interrogator. There are 8 outputs on the switch connected to the surface cables running to each of the wells.

The optical switch module is controlled over the Ethernet interface and would be connected to the Silixa local real time processing unit in the LER running Silixa's scheduling software.

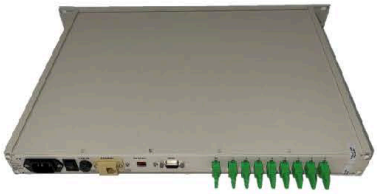


Figure 35: Optical Switch to support multiple wells

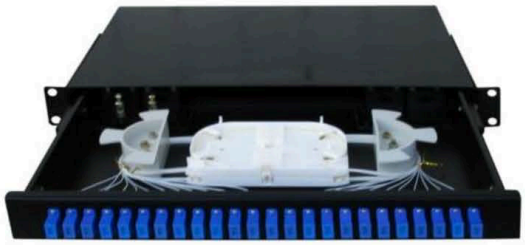


Figure 31: Fiber optic patch panel

## 5.4 Network Attached Storage - RAID Array

One 2U high, 120+TB, NAS RAID array is proposed for storage of acoustic data files in SEGY format. The RAID array is a temporary onsite storage facility for the SEGY file storage before transmitting the files to another location (should this be possible/available). This provides both a backup facility and operational buffer in case the network fails or is unable to keep up with data transmission during the seismic surveys.



Figure 32: NAS RAID data storage

## 5.5 Time Synchronization

A GPS antenna and splitter will be added to the cabinet to provide accurate timing for file synchronization across all equipment. The equipment set consists of GPS antenna, 8-way GPS splitter, lightening protector, coax cable, various short cables to connect from 8-way splitter to DAS, DTS equipment and NTP server.

All DAS equipment will receive accurate timing from the GPS antenna via the 8-way splitter. All other equipment, such as DTS, Processing Unit, etc. will receive accurate timing via NTP server.



Figure 33: GPS splitter

## 5.1 Processing Unit

One slim 1U Edge processing units with two processors, as shown in Figure 29, is proposed for running the application and processing software. We would recommend the Silixa edge processing software for:

- Scheduler to control acquisitions
- SEGY data convertor for active seismic acquisitions
- QA/QC viewer
- DTS data processing
- iDSS data processing
- Microseismic detection



Figure 29: 1U Processing unit showing two server cartridges being removed on right hand side.

## 5.2 Network Switch

One 10G network switch with both SFP and RJ45 connections will be supplied to network together all equipment in the cabinet, as well as allow connection to the 4G network for data transfer and remote connectivity.




Figure 30: Network switch

## 5.3 Fiber Optic Patch Panel

A fiber optic patch panel will be needed in each cabinet to manage the connections between the surface transit cable and the Silixa instrumentation. Silixa will be responsible for terminating and splicing the cable in the equipment room to the patch panel.

# 5 Acquisition Hardware

A representative example layout of the monitoring cabinet is shown in Figure 28: , showing the front, side and rear view of the cabinet we are proposing for this project. The cabinet includes:

- DAS interrogator (Carina DAS)
- Ultima DTS
- iDSS
- Processing unit
- Network Switch
- Fiber optics Patch Panel
- RAID Storage
- NTP Server
- Optical Switch

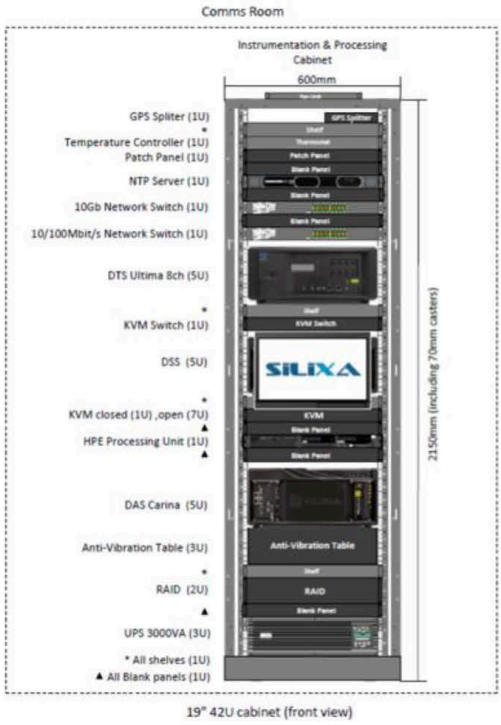



Figure 28: Example of a Monitoring Cabinet Layout

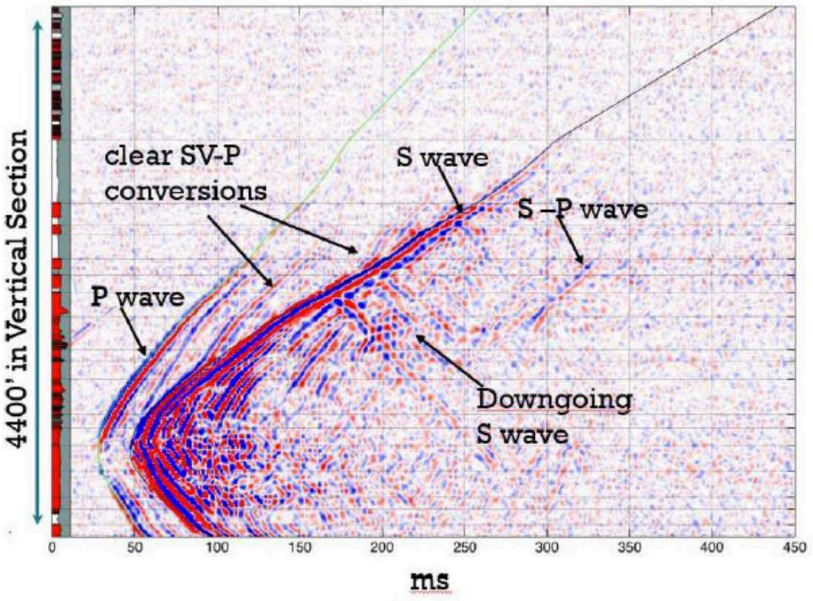



Figure 27: Microseismic event detected on Silixa iDAS.

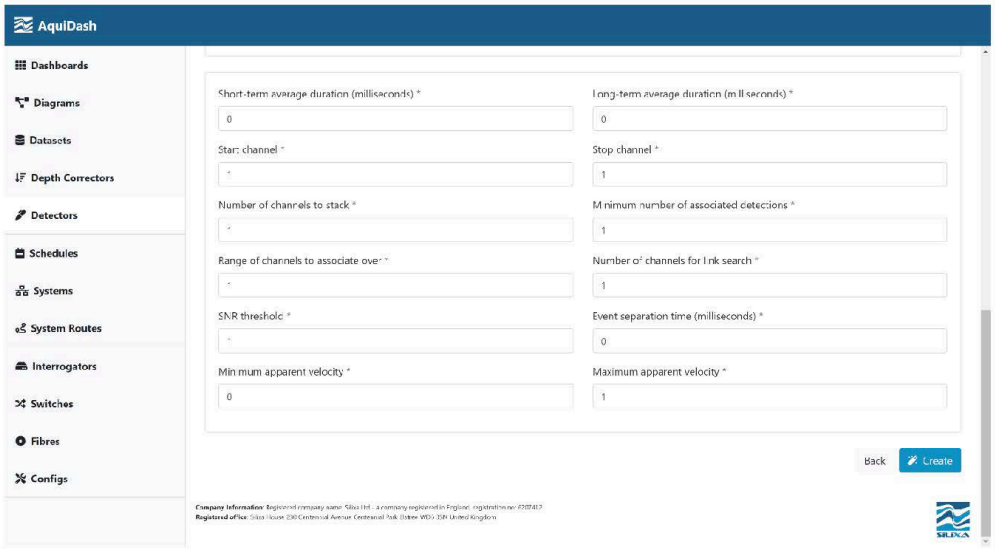



Figure 25: Microseismic Detector configuration in Silixa Edge Platform

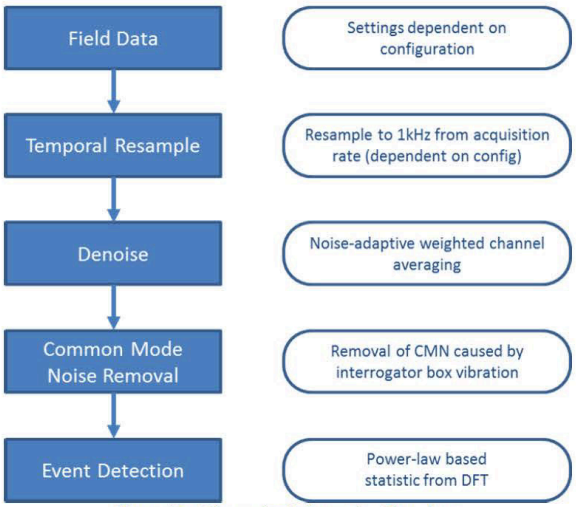



Figure 26: Microseismic Detection Flowchart

## 4.4 Seismicity

A baseline seismicity assessment is an important tool to enable an assessment of potential induced seismicity during $CO_2$ injection. To fully understand the effects of injection activities it is essential to monitor a site for background seismicity. The location of background seismicity highlights active faults and hence enables a seismic risk assessment. Seismic monitoring can help identify active faults that are not observed in 3D seismic data.

### 4.4.1 Seismicity Monitoring (Microseismic)

The risks posed by seismicity are discussed below and the monitoring solutions presented.

Microseismic events are analogous to small earthquakes and generally have magnitudes (M)<0. This type of seismic event occurs naturally, but can also be induced by anthropogenic activities, particularly in scenarios where fluid/gas are injected into the subsurface. Microseismicity can occur on pre-existing faults and fractures, but fractures may also be created by hydraulic fracturing in the injection process. $CO_2$ storage reservoirs are often chosen because they are thought to have high injectivity. Therefore, large volumes of fluid may be injected without exceeding the pressure required for hydraulic fracturing at the injection point or in the surrounding formation. If this is the case, $CO_2$ storage projects are not expected to result in significant microseismicity. If microseismicity is detected, it could indicate the reactivation of a pre-existing fracture network, which could trigger enhanced monitoring to ensure storage integrity.

The energy released by microseismicity is small and it is necessary for monitoring equipment to be in close proximity (within 100s meters) to the events because the waves are quickly attenuated. Therefore, borehole monitoring is a good option because the array can be placed at or close to the injection depth. With multiple monitoring wells precise event locations can be determined over the required area. Well-determined seismic event locations aid the geomechanical interpretation of the effects of injection, an important aspect of verifying geological and geomechanical modelling of injection scenarios.

A microseismic array for CCS projects should cover a wide aperture (i.e. provide event detection over a range of directions and angles) because microseismic events may result from stress effects and pore pressure changes at significant distances from the injection point. DAS downhole monitoring provides coverage over the full length of a borehole, while geophone arrays are often restricted to a small number of instruments covering a specific depth interval.

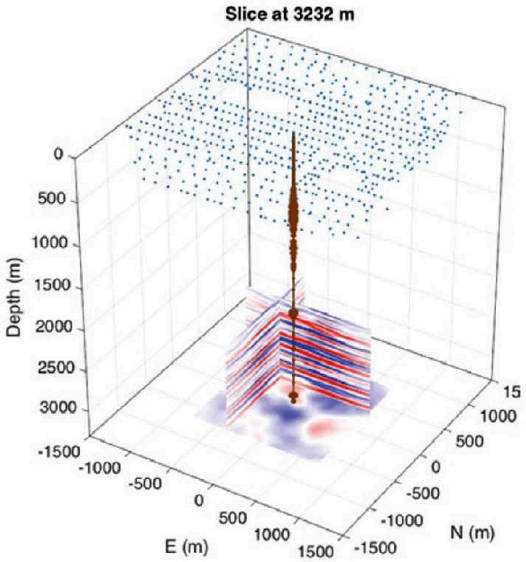



Figure 23: 2D slices from a 3D migrated DAS VSP (Miller et al., 2016).

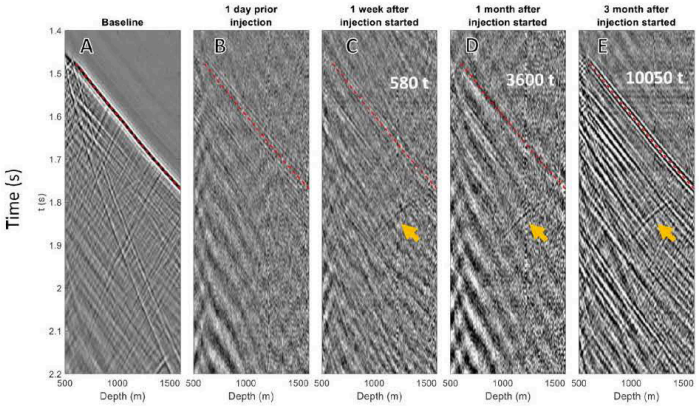



Figure 24: Timelapse effect of CO2 injection. Baseline acquisition shown in Panel A, difference plots in Panels B, C, D, E (amplified by a factor of 10).

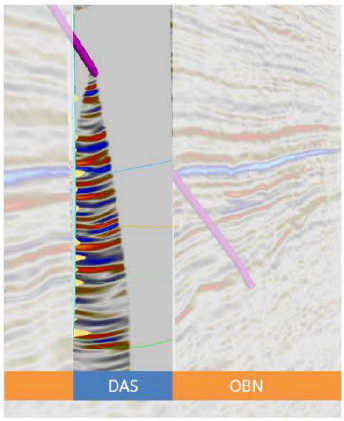



Figure 21 : Example results from an offshore DAS VSP survey, compared to results from an ocean-bottom node (OBN) array.

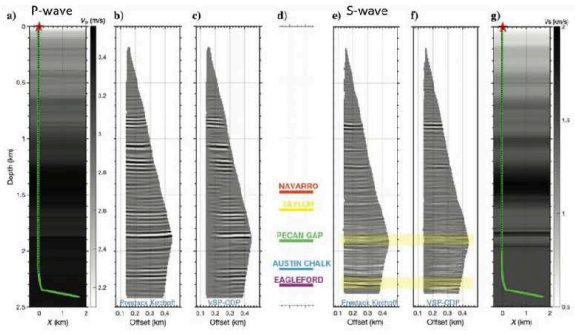



Figure 22 : P-wave (left) and S-wave (right) VSP surveys (from Cheng et al., 2021).

3D VSP surveys provide high resolution three-dimensional imaging around the borehole and can be used to resolve subtle structural and stratigraphic structures; calibrate surface seismic data; and calibrate data derived from well logs. An example of a DAS 3D VSP is shown in Figure 23: . Repeat or time-lapse 4D VSP surveys are a powerful tool for reservoir surveillance over time. Thanks to its relatively low cost, 4D with DAS is an attractive proposition for frequent seismic monitoring around production and injection wells.

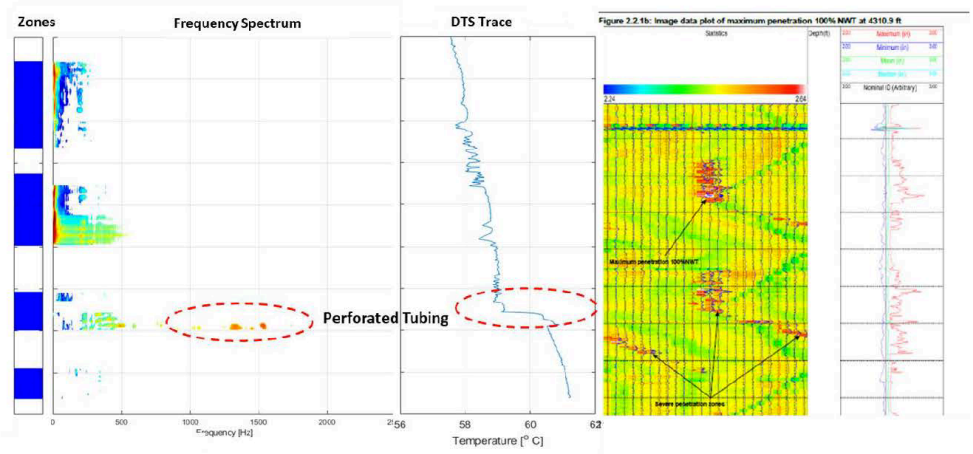



Figure 20 : Tubular failure identified by acoustic (left) and temperature (right) anomalies.

By detecting thermal anomalies or unexpected increases in in regions of the well bore it possible to identify and position leaks within the borehole. This process can be automated and be configured to provide alarms to the well operator.

## 4.3 $CO_2$ Plume Monitoring

### 4.3.1 On-Demand DAS-VSP Surveys

VSP surveys with fiber optics are among the best ways to generate detailed structural information for CCS sites due to their ability to provide highly dense spatial sampling and produce well-resolved models in a relatively short timescale. Data is collected over the full-length of the well simultaneously with a single fiber.

Time-lapse seismic is a way of using a series of seismic images of a reservoir through time to monitor changes in a survey area. It is possible to create these images through either multiple 3-D surface or VSP surveys. By viewing time-lapse data, both the storage reservoir and the overburden can be monitored. Changes in the seismic response to a $CO_2$ plume can be monitored and assessed. This geophysical exploration method is especially critical for safety monitoring at $CO_2$ sequestration sites because it makes it possible to view the migration of $CO_2$ over time. Repeatable and accurate monitoring is critical for risk management of $CO_2$ injection.

Monitoring surveys are repeated as often as necessary to capture the plume evolution.

Figure 21 shows example results from an offshore DAS VSP survey. The data agree with, and even give more detail than, the data from the ocean-bottom node (OBN) survey. Both P- and S-wave imaging surveys can be performed with DAS VSP (Figure 22).

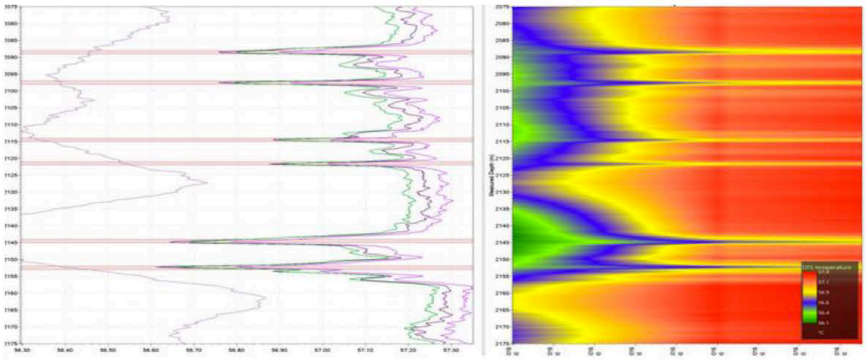


Figure 19 : Temperature profile

Temperature data is collected continuously and an integrated system monitors variation of the temperature signals against the expected range of temperature. If temperature readings occur outside the expected range, an alarm is triggered, and a signal is sent to the operators to assess the data and take any required actions.

### 4.2.2 Strain Monitoring

Continuous strain data acquisition along $CO_2$ injector and monitoring wells can provide important information about the wellbore integrity and plume development due the poroelastic response of the reservoir and surrounding formations. The development of strain as a function of depth-time can be used to diagnose wellbore integrity issues, monitor plume development vertically, and also monitor lateral development through analyses of the poroelastic response at monitoring well locations. The ULTIMA DTS data is used to calibrate the strain response to remove the thermal component of strain.

### 4.2.3 Acoustic 'noise' profiling

A plan to continuously monitor fiber optic cable installed in a $CO_2$ injection well using acoustic 'noise' profiling from DAS can be leveraged to notify operators of any damage to the wellbore along the full depth of installed cable. This could include damage to plugs or valves, casing, grout, or the surrounding formation. Since the location of any such damage can be localized to within a few meters, decision making is well informed when assessing the potential severity of continued injection operation.

The flow of high-pressure fluids through well perforations (either intended or accidental) has a well-defined acoustic signature. Acoustic data can be monitored for the onset and evolution of such leakage signals. The location of leakage is easily identifiable in the acoustic data and the severity of leakage can be parameterized by the power distribution of the frequency spectrum.

# 4 Applications

## 4.1 Introduction

The software implementation framework includes remotely accessible control software for all survey types, a custom user interface that allows for an adaptive acquisition scheduler, a set of automatic data processing and management tools, and KPI monitoring tools.

Silixa offers a set of dedicated and customized tools for data acquisition. The initial framework offers well integrity monitoring based on continuous temperature and acoustic profiling, automatic seismic (microseismic) event detection, and $CO_2$ plume mapping based on on-demand DAS-VSP surveys.

The framework for data acquisition, survey scheduling, and data management is shown below. This framework is for illustration purposes only; the workflow and parameters selection of the *Data Processing Components* must be properly designed.

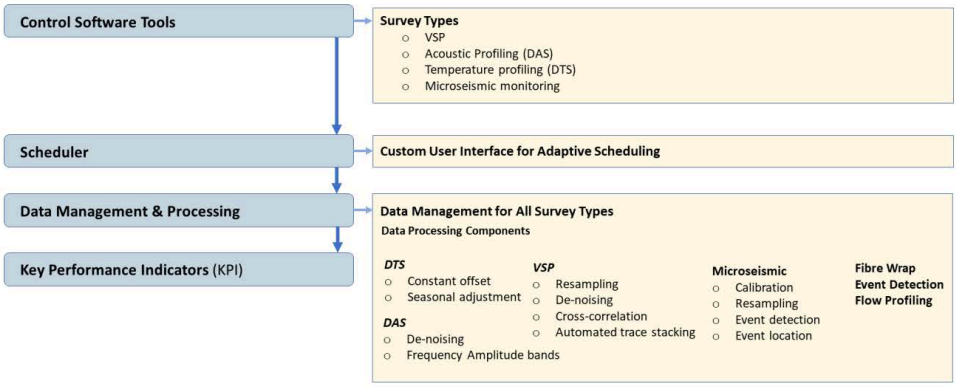



Figure 18 : Generic framework for data acquisition, survey scheduling, and data management.

## 4.2 Well Integrity Monitoring

### 4.2.1 Temperature Monitoring

Continuous temperature data acquisition along $CO_2$ injector and monitoring wells can provide important information about the wellbore integrity or plume migration. The temperature difference between the injected $CO_2$ and the reservoir temperature serves as a tracer to indicate locations of $CO_2$ leakage along the well. At the surface, the optical fibers are connected to a DTS unit can be deployed in different operational environments to provide high-resolution temperature data.

## 3.8 Cable Design

Silixa can incorporate our engineered **Constellation** optical fiber into a variety of downhole cables including the design proposed. The fiber optical cable is typically designed with two multimode fibers, two singlemode fibers, and one Silixa's engineered Constellation fiber all in a ¼" O.D. A825 tube construction. The cable is to be permanently installed on the casing. The fiber optic cable will be secured to the casing using cross coupling clamps that both protect and secure the cable in place. At the top of the casing the cable will be fed through the casing hanger and out of the wellhead. The wellhead design should consider the fiber optic cable. From the well head the optical fiber will be routed back to a data acquisition location.

### 3.8.1 Constellation fiber

The scattering properties of optical fiber can be engineered to deliver better DAS performance A SNR improvement of 20dB can be achieved, along with a wider dynamic range, using engineered fiber with precisely uniform scattering centers. This approach differs from a simple increase in irregular backscattering intensity. We also consider the trade-offs between spatial resolution, signal-to-noise performance and frequency response, and present data acquired from several different seismic and microseismic surveys. DAS performance is largely governed by how much light can be usefully collected from the optical fiber. In general, we require low loss fiber for long range sensing, but higher scattering fiber to generate more light. These two apparently contradictory requirements can be balanced by engineering bright scatter centers in the fiber, without introducing significant excess loss for the forward propagating light. The results from VSP surveys demonstrate that DAS with engineered fiber has the potential to provide similar, or even superior, quality data sets as from conventional geophones. An important aspect is that, due to the higher spatial sampling, DAS data has the capability to provide more detailed velocity information compared to geophones.

Schlumberger

# Slimline Single-Phase Reservoir Fluid Sampler

## Collect contaminant-free, representative, single-phase HPHT fluid samples

**Temperature:**
354 degF [179 degC]

**Test Pressure:**
30,000 psi [207 MPa]

**Working Pressure:**
20,000 psi [138 MPa]

**Sample Capacity:**
18.3 $in^3$ [300 $cm^3$]

### Applications

- Advanced or routine PVT and compositional analysis
- Flow assurance measurement (asphaltene, wax, and paraffins)
- Heavy oil sampling
- Near-saturated reservoir sampling
- Sulfur- and mercury-species analysis
- Routine, HP, HT, high-$H_2S$, deepwater, and arctic downhole reservoir sampling

### How it improves wells

By enabling reservoir fluid sampling directly in the flow stream, the slimline single-phase reservoir fluid sampler (SLS) captures contamination-free representative fluids, which are maintained in single phase during retrieval to surface. The optional high-shrinkage chamber (HSC) further reinforces recovery performance for highly compressible sample fluids. These sampling capabilities make it possible to conduct accurate advanced and routine PVT and compositional analyses on the entire range of reservoir fluids, even from demanding environments such as HPHT, high-$H_2S$, and deepwater reservoirs.

### How it works

The slimline single-phase reservoir fluid sampler (SLS) is an advanced HPHT-rated system for subsurface sampling applications. Each INCONEL® SLS independently maintains every sample in single-phase condition and above reservoir pressure as the tool is retrieved to surface because it has its own small nitrogen gas charge. When the optional HSC is used instead of the nitrogen chamber of the SLS for operations with highly compressible sample fluids, the extended chamber enables maintaining the sample at a higher surface pressure with a lower charge pressure. Samples are collected directly in the flow stream with no contamination for more accurate reservoir characterization, including

- GOR value
- trace elements
- different flow periods.

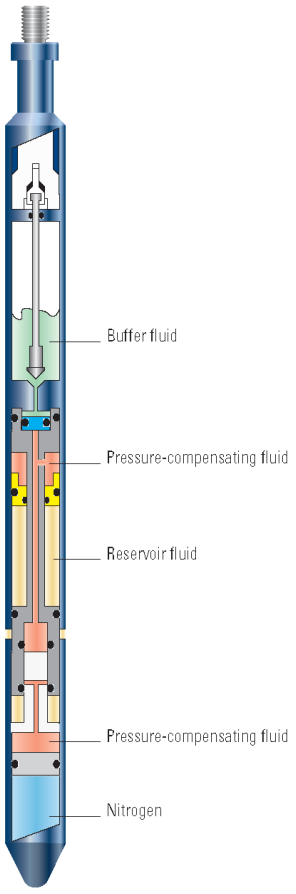
Challenging questions related to $H_2S$ and the concentration of other sulfur species can be reliably addressed by applying unique, latest-generation, nonreactive coatings such as Dursan®. When applied to the SLS sampling tools, this coating inhibits the loss of $H_2S$, increases durability, and eliminates the need for frequent recoating; as a result, reliable data can be obtained when critical decision making is required.

The SLS is conveyed with the SCAR* inline independent reservoir fluid sampling system during downhole reservoir testing operations. SCAR sampling enables obtaining high-quality PVT samples when running wireline is not cost-effective, practical, or safe. By eliminating the need for wireline intervention, SCAR sampling provides potential rig-time savings of 8 to 24 h during an offshore bottomhole sampling project.

The SLS technology is based on the original mercury-free single-phase reservoir sampler (SRS), which has been successfully operated for almost 20 years. The reliability of the SRS and SLS has established these technologies as the benchmark tools for all subsurface sampling operations.

The SLS allows controlled, contaminant-free reservoir-representative fluid samples without sample flashing. The unaltered sample is retrieved at the surface in single-phase state, requiring no recombination before transfer. Because samples need not be recombined, the sample transfer takes minutes instead of hours.

The SLS mercury-free, pressure-compensating bottomhole sampling tool can be operated in configurations of up to eight tools in each SCAR sampling assembly. As a component of Symphony* live downhole reservoir testing united by Muzic* wireless telemetry, samplers are activated using wireless commands or annulus pressure to rupture disks. This activation enables collecting samples at any time during the flow period. Samplers can be simultaneously or selectively activated for more flexibility during operations. In addition, Schlumberger provides a total chain of custody for your samples.




*Slimline single-phase reservoir fluid sampler.*

# Slimline Single-Phase Reservoir Fluid Sampler

## Features

- Samplers positioned directly inline of flow stream
- Independent nitrogen gas charge
- Simultaneous or selective firing using annular pressure or wireless commands
- Downhole self-closure of samplers
- No sample flashing
- INCONEL samplers
- Dursan nonreactive coating
- Mercury-free operation
- Fast sample validation, analysis, expertise, and support with chain-of-custody sample-management tracking
- Dangerous goods and hazardous material labeling and packaging service
- Fluids- and reservoir-domain expertise and support

**Specifications**

| | SLS-20K | SLS-HSC |
|---|---|---|
| Length, ft [m] | 12.1 [3.7] | 13.7 [4.1] |
| Max. OD, in [mm] | 1.2 [30.5] | |
| Sample capacity, $in^3$ [$cm^3$] | 18.3 [300] | |
| Material | Iconel 718 | |
| Test pressure, psi [MPa] | 30,000 [207] | |
| Working pressure, psi [MPa] | 20,000 [138] | |
| Working temperature, degF [degC] | 354 [179] | |
| Service (NACE MR0175/ISO 15156) | $H_2S$, acid | |
| Design code | API Spec 6A, NACE MR0175, ISO 15156 | |
| Certifying authority | Bureau Veritas | |

All specifications are subject to change without notice.

slb.com/welltesting

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# APPENDIX F—UNITIZATION ORDER

# APPENDIX G—FINANCIAL DEMONSTRATION PLAN

Exhibit 1—Cost Estimates for Emergency and Remedial Response Section and Event-Based Risk Activities

Exhibit 2—Pollution Support Letters – Marsh

Exhibit 3—Specimen Policy and Certificate

Exhibit 4—Surety Bond Letter - Berkley Surety

# Tallgrass Energy

# Eastern Wyoming Spirea Project

## Written Financial Assurance Cost Estimates in Support of:

Section 26(b)(i)(E) Emergency and Remedial Response

Section 26(b)(ii)(A)-(G) Event-Based Risk Activities
*(Risks 1 through 7 of the Risk Activity Table in Appendix A of Chapter 24)*

**Prepared for:**

**Tallgrass Energy**

**Eastern Wyoming Spirea Project**

**Prepared by:**

**Industrial Economics, Inc.**

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## 1.0 INTRODUCTION

This report provides written Financial Assurance Cost Estimates for the Eastern Wyoming Spirea Sequestration Project located near Carpenter, Wyoming (hereinafter, the Spirea Project).[1] The estimates conform to the regulatory requirements promulgated at Wyoming Water Quality Rules (WWQR) Chapter 24: Section 26(b)(i)(E) Emergency and Remedial Response, and Section 26(b)(ii)(A)-(G) Event-Based Risk Activities (Risks 1 through 7 of the Risk Activity Table in Appendix A of Chapter 24). These estimates are intended to inform the face amount of financial assurance(s) necessary to satisfy emergency and remedial response actions, and the stated event-based risk activities summarized in Appendix A of Chapter 24.[2,3]

Estimating financial assurance cost estimates for possible emergency and remedial responses, as well as actions to address the event-based risk activities contemplated in Appendix A of Chapter 24 necessitates understanding of the interactions between the carbon capture and underground storage (CCUS) stream, the geophysical environment in which it will be stored, and nearby populations. The long-term nature of such projects, the low (but not zero) probability of a release event occurring that may require emergency and remedial response, variability in potential incident conditions at the site, the size of the potentially impacted population, and likely exposure pathways (among other factors) inform the following emergency and remedial response cost estimates.

As described in more detail below, we combine readily available information with the results of Monte Carlo analysis tailored to project-specific risks and uncertainties to generate reasonable upper bound estimates of financial assurance costs related to emergency and remedial response and WWQR event-based risk activities. Importantly, model results will vary with factors that would be expected to impact project risk, such as: the purity of the sequestration stream and degree to which any co-contaminants might result in additional emergency response challenges; the duration of injection and post-injection site care activities; the number of wells present in the Area of Review (AOR) that extend below USDWs and the proportion that penetrate caprock; population density and the type/extent of private water well use; the presence and size of community/municipal water systems; and the use and length of new pipelines to transport captured CO2 to injection well locations. In our view, the following analyses and resulting cost estimates provide a reasonable, conservative, and objective basis for determining the face amount of financial assurance instrument(s) necessary to support a Class VI permit consistent with Wyoming regulation.

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[1] The Spirea Project comprises a single injection well: Spirea I-1 at latitude/longitude (NAD83): 41.052367, -104.424469. The project sponsor indicates that the Spirea Project AOR borders but does not overlap with the Tallgrass Energy Eastern Wyoming Sequestration (EWS) Hub Project. The Spirea Project financial assurance cost estimate presented in this document is 'stand-alone' and does not overlap with the separate and distinct financial assurance cost estimate developed for the Tallgrass EWS Hub Project. As such, it is possible to add the two face amounts together to arrive at a combined financial assurance coverage value across the projects.

[2] Per WWQR Chapter 24, Section 26(b), financial assurance cost estimates (including those that address emergency and remedial response) must be updated annually, or within 60 days of receiving notice that the Administrator has determined that a demonstration of financial assurance is not adequate. Consistent with Section 25(a)(i) and (a)(ii) requirements, ERR cost estimates also will need to be reevaluated after any updates to the emergency and remedial response plan.

[3] In general, because "accidents and unplanned events" are typical insurable events that are covered through the company's general liability coverages, they are not addressed further in this analysis. Financial assurance cost estimates for well capping and permitted abandonment, and removal of above-ground facilities and site reclamation are addressed elsewhere in the Tallgrass submission, and therefore are not addressed further in this analysis.



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The cost estimation method applied to the Spirea Project is based on the peer-reviewed approach pioneered by Industrial Economics, Incorporated ("IEc"); this approach has been used to inform estimation of emergency and remedial response costs in previously approved Class VI permits.[4] IEc tailored the valuation parameters of its Carbon Capture and Storage stochastic Monte Carlo model ("CCSvt model") to reflect site-specific factors associated with the Spirea Project. Specifically, the model's input parameters reflect the geologic location and specific chemical composition of the project's CCUS stream, as well as site-specific conditions that exist within the established area of review. The analysis adopts several conservative input assumptions and incorporates probabilistic calculations that allow for multiple release incidents through operation and post-injection site care. Cost estimates are based upon generally accepted actions to address the types of events identified in WWQR Chapter 24 Section 26(b)(ii) and the Risk Activity Matrix identified in Section 26(b)(iii) and supported by WWQR Chapter 24 Appendix A.

Based on a model run of 50,000 Monte Carlo trials **we estimate an upper-bound financial assurance cost estimate to satisfy emergency and remedial response and WWQR event-based risk activities of $5.3 million in current 2023 dollars.** This upper-bound cost estimate reflects the single Monte Carlo trial with the greatest financial assurance costs out of the 50,000 trials run. We believe this estimate to be reasonable and appropriately conservative. In the sections that follow, we discuss the basis for our cost estimates in greater detail.

## 2.0 WWQR CHAPTER 24 SECTION 26: FINANCIAL ASSURANCE COST REQUIREMENTS

The Wyoming regulations promulgated under Chapter 24 Section 26 require demonstration of financial responsibility, and specifically that owners or operators of Class VI wells establish, demonstrate, and maintain financial responsibility for emergency and remedial response pursuant to Section 25 of the Chapter. In deriving the financial assurance cost estimate, owners and operators of Class VI wells must consider the Risk Activity Matrix in Appendix A of Chapter 24, which includes the following array of event-based risk activities:

A. Contamination of underground sources of water including, drinking water supplies;
B. Mineral rights infringement;
C. Single large-volume release of carbon dioxide that impacts human health and safety or that causes ecological damage;
D. Low-level leakage of carbon dioxide to the surface that impacts human health and safety or that causes ecological damage;
E. Storage rights infringement;
F. Property and infrastructure damage, including changes to surface topography and structures;
G. Entrained contaminant releases of contaminants other than carbon dioxide;
H. Accidents and unplanned events;
I. Well capping and permitted abandonment; and

[4] This approach informed the ERR coverage estimates for the Class VI permits in North Dakota, including for example, Dakota Gasification Company (Case No. 29450), Red Trail Energy, LLC (Case No. 28848) and Blue Flint Sequester Company, LLC (Case No.: 29888). See Trabucchi, C., Donlan, M., Sprit, V., Friedman, S. and Esposito, R., 2014, 'Application of a Risk-Based Probabilistic Model (CCSvt Model) to Value Potential Risks Arising from Carbon Capture and Storage', Energy Procedia 63 (2014) 7608-7618, https://www.sciencedirect.com/science/article/pii/S1876610214026101. See also Trabucchi, C., Donlan, M. and Wade, S., 2010 'A Multi-Disciplinary Framework to Monetize Financial Consequences Arising from CCS Projects and Motivate Effective Financial Responsibility', International Journal of Greenhouse Gas Control 4 (2010) 388-395, https://www.sciencedirect.com/science/article/abs/pii/S1750583609001108. See also Trabucchi, C., Donlan, M., Huguenin, M, Konopka, M., Bolthrunis, S., 2012, Valuation of Potential Risks Arising from a Model, Commercial-Scale CCS Project Site: Prepared for GCCSI and the CCS Valuation Sponsor Group, June 1, 2012, https://www.globalccsinstitute.com/archive/hub/publications/40831/iec2012valuationofpotentialrisks.pdf.

J. Removal of above-ground facilities and site reclamation.

This report focuses on financial assurance cost estimation for Section 26(b)(i)(E) Emergency and Remedial Response, and Section 26(b)(ii)(A)-(G) Event-Based Risk Activities – Risks 1 through 7 of the Risk Activity Table in Appendix A of Chapter 24, (hereinafter WWQR event-based risk activities). As previously noted, because "accidents and unplanned events" are typical insurable events separately covered through the company's general liability coverages, they are not addressed further in this section. The exception are accidents and unplanned events that may endanger an underground source of drinking water, or threaten human health, safety, or the environment. In addition, financial assurance cost estimates for well capping and permitted abandonment (I), and removal of above-ground facilities and site reclamation (J) are addressed elsewhere in the Tallgrass submission, and therefore are not addressed further in this report.

## 3.0 MONTE CARLO APPROACH TO FINANCIAL ASSURANCE COST ESTIMATION

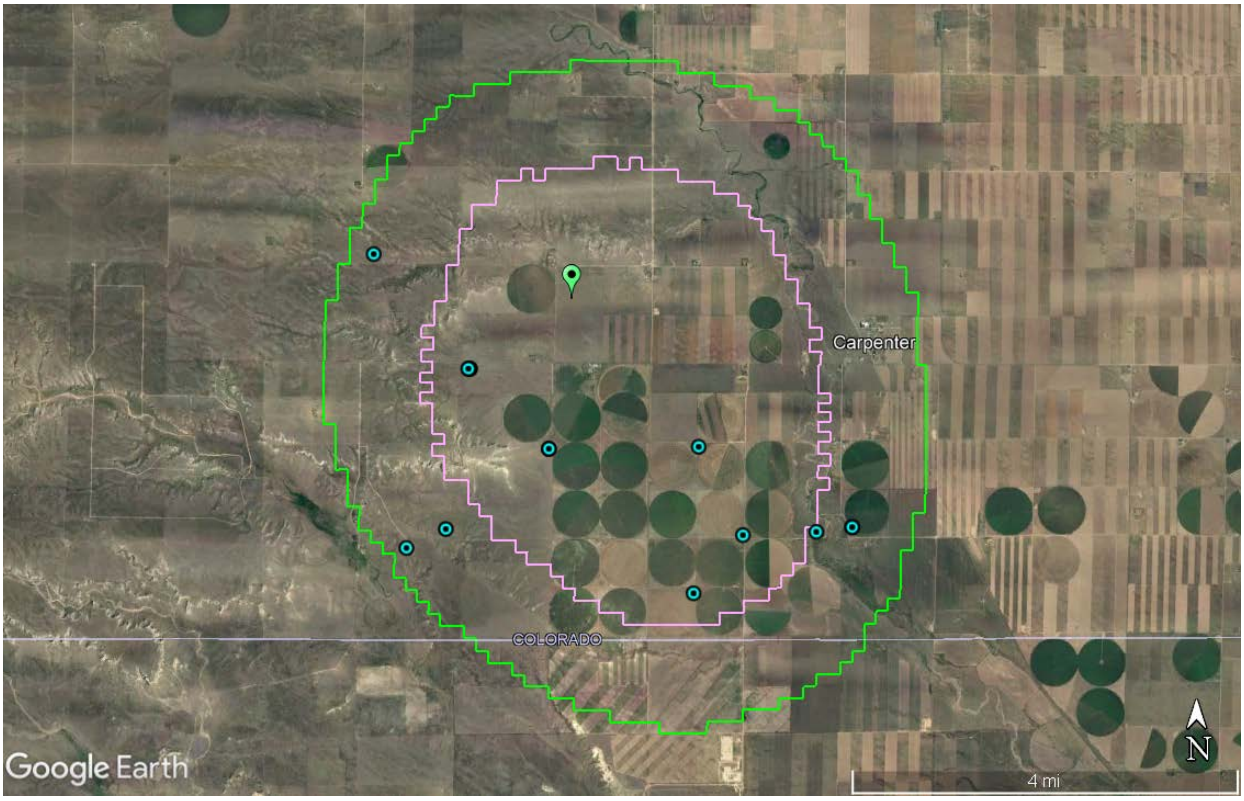
We estimate the cost of emergency and remedial response actions and WWQR event-based risk activities by tailoring the valuation parameters underpinning the CCSvt model to reflect site-specific factors associated with the Spirea Project. The CCSvt model published in the peer-reviewed technical literature leverages Monte Carlo (i.e., risk-based, probabilistic) modeling and site-specific scenario analysis (Trabucchi et al., 2014). In our view, Monte Carlo analysis is particularly well suited to the evaluation of potential costs arising from low probability events over long periods of time. As described in Trabucchi et. al (2014), key parameters which inform the CCSvt model inputs include identification of release event types and probabilities, the duration of injection and post-injection/site closure (PISC) activities, and cost distributions for anticipated response actions if ERR incidents or WWQR event-based risk activities occur.

This approach is explicitly consistent with WWQR Chapter 24 Section 26 (b)(iv) requirements, which state: "*the financial assurance cost estimate shall be based upon a multi-disciplinary analytical framework such as Monte Carlo or other commonly accepted stochastic modeling tools*." The section goes on to state that: "*cost curves shall combine risk probabilities, event outcomes, and damages assessment to calculate expected losses under a series of events;*" and, "*for all cases of potential damages, the probability distributions should be identified for 50 percent, 95 percent, and 99 percent probabilities of occurrence.*" The analyses underpinning this report conform to these requirements.

## 4.0 AREA OF REVIEW

Consistent with WWQR Chapter 24 Section 26(b)(7), the information and analyses underpinning the estimation of financial assurance costs reflect the AOR for the Spirea Project, as shown in Exhibit 1 (delineated by the green line). Exhibit 1 also reflects the maximum extent of the CO2 plume, critical pressure increase, or the maximum combination of the two (shown by the purple line) and incorporates a one mile buffer (delineated by the green line). For context, Exhibit 1 also shows the location of the injection well (green tear drop) that comprise the Spirea Project, as well as oil and gas wells in the AOR (blue circles).

**Exhibit 1. Area of Review**




## 5.0 DURATION OF INJECTION AND POST-INJECTION SITE CARE (PISC) ACTIVITIES

The financial assurance cost estimates reflect: (1) a 17-year CO2 injection period, (2) a 30-year PISC period, and (3) the possibility of having to address risk-based event activities that potentially could occur during the operational and PISC project phases, necessitating emergency and remedial response action. Consistent with these assumptions, the Monte Carlo calculations incorporate an overall project timeline of 47 years (i.e., 17 years of injection, plus 30 years of PISC). Financial assurance cost estimates are provided for the entirety of the project timeline, as well as by project phase.

## 6.0 RISK EVENT TYPES AND PROBABILITIES

### 6.1 Leakage through Wells, Caprock, and Faults

Exhibit 2 identifies the risk event types and probabilities used to estimate emergency and remedial response costs arising from well leaks and leakage through caprock, existing faults and induced faults. We base annual release probabilities on the Final Risk Assessment Report for the FutureGen Project Environmental Impact Statement, revised April 2007.[5] These data reflect extensive, federally-funded analysis, are publicly available, and informed the U.S. Department of Energy's development of an Analog Site Database regarding the release of CO2 from existing injection sites and natural releases.[6] The Analog Site Database includes information from four existing CCUS sites, 16 natural CO2 sites in sedimentary rock formations, and 17 sites in VHM (volcanic, hydrothermal, and metamorphic) areas. These sites have been identified in several natural analog investigations for CCUS.

[5] See https://www.energy.gov/sites/prod/files/EIS-0394-DEIS-RiskAssessmentReport-2007.pdf, p. 6-15, Table 6-11.
[6] Ibid, pg 5-1.

In addition to leakage from reservoirs via natural pathways, the FutureGen efforts considered leakage information from myriad CCUS risk assessments and developed a well failure-release event database, which reflects applied experience from the natural gas storage industry, the oil and gas industry, and wells at natural CO2 reservoirs.

Estimates of potential consequences for the Spirea Project are informed by the annual probability point estimates resulting from the FutureGen efforts. In some cases, FutureGen provides a range of probabilities – in such circumstances, we conservatively use the highest probability in the range. Exhibit 2 reflects the release probabilities for eight types of event-based risk activities.[7] For well-related events, the identified probabilities reflect the risk of release for a single well.

As previously noted, one injection well is planned for the Spirea Project (see Exhibit 1). As noted elsewhere in the permit application, Tallgrass has determined that there are no 'deep' (i.e., deep enough to penetrate the injection zone) oil & gas wells in the AOR. However, for purposes of the Monte Carlo calculation, we conservatively assume the presence of two undocumented 'deep' oil & gas wells in the AOR. We believe that doing so provides a buffer against the possibility that records may be incomplete, and construction or natural landscape features may obscure old well locations.[8]

The project sponsor has identified 15 'shallow' (i.e., not deep enough to penetrate the injection zone) oil & gas wells in the AOR. Our Monte Carlo calculations conservatively assume the presence of two additional undocumented shallow wells.[9] We add these wells for the same reasons discussed above – a buffer against the possibility of incomplete records – resulting in a total of 17 shallow oil & gas wells for purposes of estimating consequences arising from WWQR event-based risk activities. Finally, we include the anticipated above-zone monitoring well planned for the project in the 'shallow well' category, yielding a total shallow well count of 18.

The FutureGen efforts do not provide release probability estimates for 'shallow' wells, as defined and identified for purposes of the Monte Carlo calculation. As such, we assume that shallow wells that do not penetrate the caprock have a release probability equal to twice the highest probability for caprock or fault release events. This assumption reflects the fact that CO2 or brine would need to escape through the caprock or fault before reaching the shallow well, at which point the well may yield a more direct pathway to a USDW. We believe this approach is reasonable and conservative.

The project sponsor indicates that currently no in-zone monitoring wells are anticipated. For completeness, we note that the Monte Carlo model can incorporate deep CO2 monitoring wells. FutureGen does not specifically address release probabilities for deep CO2 monitoring wells. As such, we conservatively assign an annual release probability to these wells equal to the CO2 injection wells – monitoring wells are not subject to the same type or extent of use, and therefore are likely to evince a smaller annual release probability than that assumed for purposes of this cost estimation exercise.

[7] Specified risk events could occur for a variety of reasons, including but not limited to mechanical failure, industrial activities unrelated to CCUS, incomplete/inaccurate subsurface characterization, natural or induced seismicity, other natural subsurface processes. Every WWQR event-based risk activity that occurs in the Monte Carlo analysis, whatever its underlying cause, is assumed to require an emergency and remedial response action.
[8] This adjustment for unknown wells is based on professional judgement, informed by the fact that Tallgrass has identified approximately 15 oil & gas wells in the AOR, none of which extend to depths sufficient to penetrate the injection zone.
[9] This adjustment for unknown wells is based on professional judgement, reflecting an approximately 10% increase relative to the number of known wells.

**Exhibit 2. Probabilities for Well, Caprock and Fault Leakage Events**

| Risk Event Type | Annual Probability | Number of Wells |
|---|---|---|
| Deep Oil & Gas Well Leak | 0.1% per well[a] | 2 |
| CO2 Injection Well Leak | 0.001% per well[b] | 1 |
| Deep CO2 Monitoring Well Leak | 0.001% per well[c] | 0 |
| Rapid Leakage Through Caprock | 0.00000002%[d] | n/a |
| Slow Leakage Through Caprock | 0.004%[e] | n/a |
| Release Through Existing Faults | 0.000002%[f] | n/a |
| Release Through Induced Faults | 0.000002%[g] | n/a |
| Leakage Through Caprock/Faults then Shallow Well | 0.008%[h] | 18 |

Source for risk events and annual probabilities: Final Risk Assessment Report for the FutureGen Project Environmental Impact Statement, revised April 2007, available online at: https://www.energy.gov/sites/prod/files/EIS-0394-DEIS-RiskAssessmentReport-2007.pdf, p. 6-15, Table 6-11.

Additional Notes:

a) Highest probability within FutureGen range for undocumented deep wells developed from the FutureGen analog database.
b) Highest probability within FutureGen range for CO2 injection wells developed from the FutureGen analog database.
c) Conservatively assumed to be equal to CO2 injection well leak probability.
d) Equal to FutureGen probability for rapid leakage through caprock developed from the FutureGen analog database.
e) Equal to FutureGen probability for slow leakage through caprock developed from the FutureGen analog database.
f) Equal to FutureGen probability for release through existing faults developed from the FutureGen analog database.
g) Equal to FutureGen probability for release through induced faults developed from the FutureGen analog database.
h) Conservatively assumed to be twice as likely as the highest caprock/fault probability.

## 6.2 Pipeline Releases

The Monte Carlo calculations underpinning this cost estimation exercise include potential costs associated with pipeline release events. The annual pipeline release probability used in the model is based on U.S. Department of Energy Pipeline and Hazardous Materials Safety Administration (PHMSA) data for CO2 pipeline release incidents. PHMSA has compiled pipeline incident data since 2002. In 2020, there were approximately 5,100 miles of CO2-carrying pipeline in the U.S., up from about 3,400 miles in 2004. There were 103 CO2 pipeline accidents recorded from 2002 through 2021. Those figures result in an annual release probability of 0.12% per pipeline mile. It is our understanding that approximately 8.5 miles of new CO2 pipeline currently are anticipated for the Spirea Project. The added pipeline is to allow for transport of the CCUS stream from the source facility to each injection well location. A reasonably conservative 1.02% annual pipeline release probability is used in this analysis.[10]

## 6.3 Induced Seismicity

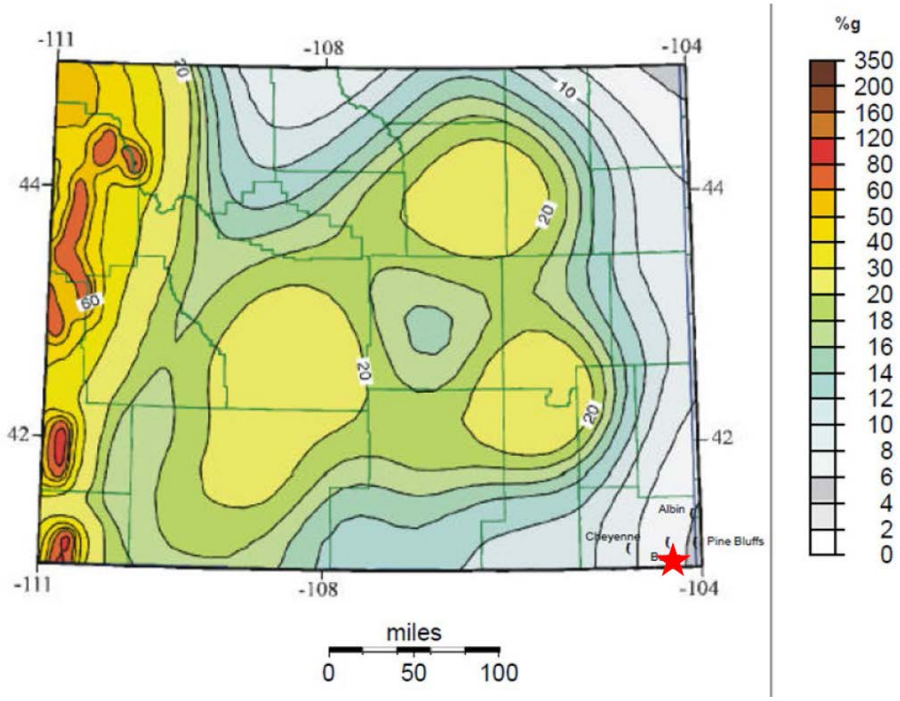
We have been unable to identify any record of induced seismic events in the Spirea Project area. The project sponsor conducted an evaluation of seismic activity for Laramie County, which indicates that the project is in an area of low seismic activity. Exhibit 3 shows the 2% probability of exceedance in 50 years and range from 5% to almost 14% peak ground acceleration in southeastern and northwestern Laramie County, respectively.

Induced seismicity of sufficient magnitude to potentially damage infrastructure most commonly occurs in areas with a history of extensive deep injection of fluids from nearby oil and gas operations.[11] As described throughout this document, the project AOR has a limited history of oil and gas development. Regardless, for financial assurance cost estimation purposes, we conservatively assume a probability and magnitude of

[10] 1.02% Spirea Project pipeline annual release probability = 0.12% release probability per CO2 pipeline mile * approximately 8.5 miles of new pipeline.
[11] See, for example, Rubinstein, Justin and Alireza Babaie Mahani. Myths and Facts on Wastewater Injection, Hydraulic Fracturing, Enhanced Oil Recovery and Induced Seismicity. Seismological Research Letters. July 2015.

induced seismic events equal to that for 'natural' seismic events. A 2% probability of exceedance in 50 years translates to an annual exceedance probability of 0.04%.[12]

**Exhibit 3. USGS 2,500-year Probabilistic Acceleration Map of Wyoming***




*Map contours represent a 2% probability of exceedance in 50 years.

### 6.4 Pore Space Trespass

As described elsewhere in the Tallgrass Class VI permit application materials, the project sponsor has made substantial progress obtaining pore space rights. Through the pore space unitization process, the sponsor anticipates that it will have acquired pore space rights for all subsurface areas in which injected CO2 from the injection well is expected to reside.

Based on extensive subsurface data collection, site characterization, and plume modeling efforts, the sponsor believes it is unlikely that stored CO2 will migrate to other subsurface locations. The actual movement of CO2 in the subsurface environment will be calibrated with modeled predictions on a regular and systematic basis, and therefore it is likely that any potential trespass issue would be identified prior to occurrence and the amount and/or location of ongoing CO2 injection potentially adjusted to reduce or eliminate the trespass concern. Nevertheless, for purposes of deriving a financial assurance cost estimate, we assume a 10 percent chance that trespass occurs at some point during injection and/or PISC periods, and that such trespass will necessitate a response action.[13]

## 7.0 COST DISTRIBUTIONS APPLIED TO EVENT-BASED RISK ACTIVITIES NECESSITATING EMERGENCY AND REMEDIAL RESPONSE ACTION

[12] 0.04% annual seismic probability = 2% seismic probability over 50 years / 50 years.

[13] The Tallgrass EWS Hub Project AOR borders the Spirea Project AOR. If the EWS Hub Project Class VI permit is approved, that will add an additional element of conservatism to the Spirea financial assurance cost estimate presented in this document, because trespass east of the Spirea AOR will not be possible given that Tallgrass already hold those pore space rights.

Previously peer-reviewed, published applications of the CCSvt model relied on 10,000 Monte Carlo trials. In the interest of reasonable conservatism, and for purposes of demonstrating financial responsibility in support of the Class VI permitting process, this analysis relies on 50,000 Monte Carlo trials. In our view, the reliance on 50,000 Monte Carlo trials offers an additional measure of conservatism and certainty. If a release from a WWQR event-based risk activity occurs during a Monte Carlo trial, the model randomly chooses a cost amount from the indicated cost distributions.

## 7.1 Well Repair Cost Distribution

Injection Well, Deep Monitoring Well, and Non-Project Deep Well repair cost distribution is as follows:

- Minimum: $5,000
- 10th percentile: $25,000
- Median: $62,000
- 90th percentile: $140,000
- Maximum: $1,700,000
- Burr Distribution[14]

Shallow Well repair cost distribution is as follows:

- Minimum: $5,000
- $10^{th}$ percentile: $8,100
- Median: $56,000
- $90^{th}$ percentile: $170,000
- Maximum: $500,000
- Exponential Distribution

We apply the above cost distributions to all well release incidents that occur in the Monte Carlo trials to stop leaks and prevent reoccurrence. For the Spirea Project analysis, we conservatively assume that addressing a well-related release of CO2 would involve plugging and surface reclamation.[15] As a proxy for such costs, we rely on information and analysis provided in Raimi et al (2021).[16] This peer-reviewed, publicly available analysis provides cost estimates for plugging and surface reclamation of oil and gas wells, based on data from five states (Montana, New Mexico, Kansas, Texas and Pennsylvania).

For 'deep' wells (extending more than 4,000 feet below the surface), we use a Burr distribution in which the $10^{th}$ percentile, median, and $90^{th}$ percentile costs align with those found for high cost (and generally deepest) wells in Raimi et al., (2021). We conservatively set the minimum cost to $5,000, notwithstanding the fact that costs below this amount were observed in the data set. We set the maximum cost to $1.7 million, consistent with the highest cost for well plugging and surface reclamation costs observed in the Raimi data set. For shallow wells (extending up to 4,000 feet below the surface) we assume an exponential distribution based on Raimi et al., (2021) data for all wells, but with a maximum cost of $500,000 (which reflects the highest cost for wells with depths up to approximately 4,000 feet.)

[14] The Burr distribution is commonly used to fit non-normally distributed data characterized by a right-skewed distribution (i.e., most values are clustered around the left tail of the distribution while the right tail of the distribution is longer).
[15] Plugging and surface reclamation are the most likely response measures to address a release from any inactive wells in the AOR. If an active CO2 injection well, monitoring well or industrial well was the source of a release, we assume that funds described in this section would be used to support well repair.
[16] Raimi, Daniel, A. Krupnik, J-S Shah, A. Thompson. "Decommissioning Orphaned and Abandoned Oil and Gas Wells: New Estimate and Cost Drivers. Environ. Sci. Technol. 2021, 55, 10224-10230.

We believe that these estimates reasonably characterize the distribution of potential shallow and deep well repair costs in the event well-related release events were to occur at the Spirea Project.

### 7.2 Cost Distribution for USDW Non-Endangerment

- Minimum: $50,000
- Maximum: $1,475,000
- Uniform distribution

We apply the above cost distribution to all incidents that involve a well, caprock or fault release that occurs in a Monte Carlo trial. This distribution reflects several different response components, including the characteristic use of USDWs in the AOR for the Spirea Project and the professional judgement of experts versed in federal and state response action to groundwater contamination incidents. We describe the underlying basis for this cost distribution below.

For groundwater that is intended for domestic use, Wyoming state groundwater regulations incorporate federal groundwater quality standards established by EPA.[17] The National Primary Drinking Water Regulations (NPDWRs) developed by EPA establish mandatory water quality standards for drinking water contaminants. These standards are referred to as "maximum contaminant levels" (MCLs), which are intended to protect the public against consumption of drinking water contaminants that present a risk to human health. An MCL is the maximum allowable amount of a contaminant in drinking water delivered to the consumer.

National Secondary Drinking Water Regulations (NSDWRs) set non-mandatory water quality standards for 15 contaminants. These standards (referred to as "secondary MCLs or SMCLs") are offered as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor. These contaminants are not considered to present a risk to human health at the SMCL.[18]

Consistent with these mandates, we evaluate potential consequences arising from release incidents or WWQR event-based risk activities at the project site, which could result in an exceedance of one or more MCLs in a USDW. We do so because, however unlikely, it is possible that such incidents could result in the need for an emergency and remedial response action. Our evaluation of potential consequences begins with the composition of the CCUS stream and the potential pathways for harm to USDWs.

- Composition of the CCUS Stream. Tallgrass anticipates that the CO2 injectate will meet the minimum pipeline specifications identified in Exhibit 4. For some constituents, the pipeline specification limits in Exhibit 1 do not provide enough information to assess the potential for an MCL exceedance. For example, 'hydrocarbons' may contain various polycyclic aromatic hydrocarbons (PAHs), for which there are established MCLs. To address this uncertainty, as well as the possibility for trace amounts of contaminants other than those identified in Exhibit 1, the cost distributions (discussed in later sections of this document) assume use of reverse osmosis (RO) treatment units for residences potentially affected by a release event. RO treatment units are highly effective at removing a wide variety of contaminants, including PAHs.[19]

- Potential Pathways for Endangerment of USDWs. In addition to 'direct' impacts resulting from a release of constituents present in the CCUS stream into a USDW, 'indirect' impacts could arise if

[17] See WWQR Chapter 8, Section 4(d)(v)(A).
[18] See https://www.epa.gov/sdwa/secondary-drinking-water-standards-guidance-nuisance-chemicals.
[19] For example, as noted on EPA's website "RO and NF [nanofiltration] are useful for the removal a wide range of contaminants. RO can remove contaminants including many inorganics, dissolved solids, radionuclides and synthetic organic chemicals. RO can also be used for removing salts from brackish water or sea water." https://www.epa.gov/sdwa/overview-drinking-water-treatment-technologies#RO

released CO2 reduces the USDW's pH sufficiently to increase the leaching of heavy metals from aquifer minerals at concentrations that exceed an MCL. It also is possible that increases in subsurface pressure arising from injection activities could result in USDW impacts due to resulting movement of underground brines. This analysis incorporates emergency and remedial response actions to address potential MCL exceedances that could arise in these scenarios. We anticipate that these actions also would address any aesthetic impacts (e.g., taste, color, odor, etc.) that could be associated with potential exceedance of secondary MCLs (e.g., for pH, TDS, chlorides, etc.).

**Exhibit 4. Spirea Project CO2 Pipeline Specifications**

| Constituent | Limit | Note |
|---|---|---|
| $CO_2$ | ≥ 95 mol% | |
| CO | ≤ 0.4 mol% | |
| $H_2$ | ≤ 0.5 mol% | |
| $N_2$ | ≤ 4 mol% | |
| $H_2S$ | ≤ 20 ppm | |
| Total Sulfur | ≤ 35 ppm | |
| Total NOx | ≤ 10 ppm | |
| $O_2$ | ≤ 1 mol% | |
| H2O | ≤ 150 ppm | |
| Hydrocarbons (Maximum cricondentherm dew point of hydrocarbon mix -20°F) | ≤ 4 mol % | |
| Glycol | 0.3 gallons/MMCF | |
| Maximum dew point at 400 psig | 30°F | |
| Non condensable gases | ≤ 5 mol% | Sum of $N_2$, $H_2$, $CH_4$, $O_2$, CO, Ar |

*Impurities Deleterious to Pipeline, Equipment, Downstream Systems or Reservoirs: in addition to compositional limits listed above, product shall not contain impurities deleterious to pipeline, equipment, downstream systems, or reservoirs. Impurities not listed here should be brought to the attention of $TPCO_2$ for further evaluation. Carbon dioxide delivered by anthropogenic or biogenic source that does not meet the specifications will be rejected at $TPCO_2$'s sole discretion.

Exhibit 1 provides context regarding land use within the Spirea Project AOR. As illustrated in the image, land use in the approximately 34 square mile AOR is highly rural, with a low density of scattered residences and a substantial amount of agriculture and ranching/livestock activity. There are no municipal water systems, and one population center within the AOR (Carpenter). Data provided by the project sponsor indicate that there are approximately 175 water wells distributed throughout the AOR (approximately 88 for domestic use, 68 for livestock watering (some dual-purpose domestic/livestock), and 56 for irrigation). The maximum water well depth is 520 feet. The deepest domestic well is 520 feet.

Based on the aforementioned site context, we estimate a maximum per-incident cost range tailored to the Spirea Project as follows:

- A maximum of $55,000[20] to drill new water monitoring wells, to facilitate data collection to evaluate the spatial extent, existence, and/or significance of a potential release-related plume for existing water users,[21] plus;
- A maximum of $20,000[22] for quarterly sampling and analysis for standard field measurements and heavy metals at an estimated $200 per sample,[23] including collection and analysis, for up to two years and 12 residences,[24] plus;
- A maximum of $5,100[25] for residential replacement water for one year for up to 12 residences,[26] plus;
- A maximum of $46,200 for residential replacement water for the entire town of Carpenter for up to two years in the case of an accident in the town of Carpenter,[27] plus:
- A maximum of $30,000[28] for purchase and installation of residential reverse osmosis (RO) units at up to 12 residences,[29] plus;
- A maximum of $18,000[30] for RO replacement filters, including servicing of such units at $300 per unit per year for up to five years at 12 residences,[31] plus;

[20] $55,000 = 4 wells * 550 foot depth * $25 drilling cost per foot.
[21] At an estimated drilling cost of $25 per foot (see https://homeguide.com/costs/well-drilling-cost#cost, which estimates a cost of $15-$25 per foot for drilling a water well), this cost allowance would allow, for example, drilling of four new wells at a 550-foot depth.
[22] $20,000 (rounded) = 12 residences * 8 quarterly samples * $200 per sample.
[23] See for example information from laboratory vendor Chemtech international at https://chemtech-us.com/articles/cost-of-well-water-testing-in-2021/#:~:text=It%20costs%20%24165%20at%20the,%24279%20at%20the%20full%20price, which states "the Essential Water Test is a standard test that screens the general water chemistry, the hardness and alkalinity of the water, toxic and heavy metals, nitrates and nitrites, coliform and E.coli bacteria, and silica. It costs $165 at the full price." We round up to $200 to account for potential sample collection costs.
[24] If there is a release incident, a common response measure would be to periodically test water wells within the potential impact area to determine if any residences are at risk of exposure to contaminants at levels above an MCL. If no impacts are found within two years of an incident, we anticipate that continued testing would no longer be necessary. Alternatively, if household treatment needs arose, we anticipate that treatment solutions would be implemented within two years of the incident. As a result, testing of residential wells should be unnecessary after two years.
[25] $5,100 (rounded) = 12 residences * $35 per month for 25 gallons * 12 months.
[26] If residential water well testing identifies contaminant levels of concern, replacement water for drinking and cooking would be provided for affected residents. Commercial companies offer water delivery service at approximately $35 per month for 25 gallons, a typical consumption level for a family of 3-4 (see for example pricing and family water quantity recommendations from water vendor Culligan at https://www.culligan.com/bottled-delivery/select). This pricing estimate is conservative, as it is likely that bottled water could be provided in bulk at costs lower than those charged by residential delivery services. We also note that replacement water typically is a temporary measure; in this case, if contamination issues persist for longer than one year, we anticipate that the replacement water program would end and be replaced by installation of residential reverse osmosis units to provide clean water, which is a more expensive, but more appropriate solution for longer term contamination issues.
[27] $46,200 = 55 households * $35 per month for 25 gallons * 24 months (Number of households in Carpenter from: https://censusreporter.org/profiles/16000US5612860-carpenter-wy/).
[28] $30,000 = 12 residences * $2,500 per RO unit.
[29] While some residential RO units (and other types of residential treatment technologies) can cost several hundreds of dollars, for this analysis, we assume installation of the much more expensive Kinetico K5 Drinking Water Station RO unit, which is an RO model currently designated for use in response to a severe, long-term groundwater contamination incident in North Carolina, affecting thousands of residences (see https://edocs.deq.nc.gov/WasteManagement/DocView.aspx?id=1636579&dbid=0&repo=WasteManagement). Pricing information from Consumer Reports indicates that $2,500 is a reasonable cost estimate for this unit.
[30] $18,000 = 12 residences * $300 per RO unit per year * 5 years.
[31] Annual RO unit maintenance costs will vary depending on water use, contaminant levels and other factors. Based on warranty information, replacement filter prices and professional judgement, $300 per year per unit is a reasonable approximation of annual maintenance costs. For reasons described throughout this document, we anticipate that release incidents that occur should be resolvable within months or a few years. Out of an abundance of caution, for purposes of cost estimation, we assume maintenance of RO units for five years after installation to allow for natural dilution/dissipation of any residual CO2/low pH/brine plume, supplemented by active remediation, if needed.

- A maximum of $400,000 for irrigation support,[32] plus;
- A maximum of $400,000 for ranch/livestock support,[33] plus:
- A maximum of $500,000 for additional response and remedial actions.[34]

Summing the maximum dollar amount for each of these components results in a total maximum per-release cost of $1,475,000 (rounded), in 2023 dollars.

The maximum per-release cost reflects a cost distribution for USDW non-endangerment that is tailored to the specific circumstances of the Spirea Project. We rely on a minimum cost of $50,000 for the cost distribution, reflecting the potential for small releases insufficient to cause measurable adverse impacts, or for releases that cause minor impacts, which are easily addressed at minimal cost. For estimation purposes, we assume a uniform probability distribution in the Monte Carlo trials. That is, every incident that occurs in a trial is randomly assigned a cost from the cost distribution discussed above; and every cost within that range has an equal chance of being assigned. We offer additional context for our approach below.

Evaluation of the Spirea Project suggests that the most likely pathway for a potential release that could impact a USDW in the project's AOR is migration through a well of some kind. Such releases are associated with a very specific release location; and, tend to offer a better opportunity to identify and mitigate impacts than often is available at groundwater contamination sites caused by spatially dispersed, slow infiltration of contaminants from the surface.

As previously noted, the composition of the Spirea Project's CCUS stream has a very low potential for introducing co-constituents that could directly contaminate a USDW and cause an exceedance of a health-based MCL. Rather, potential impacts from a release more likely would occur indirectly by: 1) lowering groundwater pH, which, in turn, could lead to increased dissolution of metals present in the aquifer matrix (if

[32] Information provided by the project sponsor indicates that there are approximately 56 irrigation wells within the approximately 34 square mile AOR. While difficult to forecast specific irrigation needs in response to a potential release event due to seasonal timing, weather, specific crop requirements, and other factors, $400,000 provides a significant incident-specific sum that could be used for a variety of potential response activities, including but not limited to: funding new irrigation system connections to existing, unaffected wells; digging new wells in areas away from potential release impacts and connecting them to irrigation systems; farm-specific treatment solutions; and temporary replacement water (trucked water can cost about $30-$65 per 1,000 gallons).

[33] Information provided by the project sponsor indicates that there are approximately 68 water wells within the approximately 34 square mile AOR identified as serving 'stock watering' purposes (although many also co-list 'domestic' water provision). $400,000 is a substantial sum that could, for example, allow for drilling one or more new wells in areas away from potential release impacts and connecting them to existing water delivery systems; facilitating more complex treatment solutions; enabling dilution with other unimpacted water sources; or providing temporary bulk replacement water (trucked water typically can cost about $30-$65 per 1,000 gallons). While water needs for livestock will depend on the season, type and age and other livestock characteristics, as an approximation we note that beef cattle can require 4-20 gallons of water per day, per head (see https://www.ag.ndsu.edu/publications/livestock/livestock-water-requirements). As additional context, if livestock required 10 gallons per day per head, and replacement water could be obtained for $65 per 1,000 gallons, that implies an annual replacement water cost on the order of roughly $250 per head per year.

[34] As part of the emergency and remedial response to a release incident involving a WWQR event-based risk activity, additional actions might be needed to protect USDWs, including limiting plume movement, accelerating dilution of CO2 concentrations or brine, extracting CO2 or brine-related contamination through air stripping or other technologies, buffering pH or constructing reactive barriers to limit CO2 impacts, reducing subsurface pressure by halting CO2 and/or other subsurface injection activities in relevant areas, and/or otherwise undertaking actions to speed the return of an impacted USDW to baseline conditions. This cost estimate reflects several factors: as discussed elsewhere in this document, CO2 releases or pressure-related brine movement through faulty wells is the most likely release pathway and can be relatively straightforward to stop through well repair/plugging; the aquifer matrix is likely to have meaningful buffering capacity that limit pH changes; resultant/residual plumes of groundwater with substantially reduced pH are not likely to be large or long-lived; dilution/natural attenuation can reduce CO2 and/or brine levels without intervention; CO2 is relatively inexpensive to remove from groundwater; low pH also is relatively inexpensive to address; subsurface pressure fronts can dissipate relatively quickly after the cessation of injection activities if lateral plume movement in the injection zone is not confined; "thief" zones between the injection formation and USDW can absorb CO2 or brine flux; density differences due to temperature and salinity can limit the vertical migration of displaced brine; and rural land use patterns and the low density of water wells in the AOI limit the potential for plume impacts on water users.

present in sufficient quantities); or 2) injection-related increases in subsurface pressure that results in the vertical migration of underground brines into a USDW.

Importantly, there are natural factors that are likely to limit the impact of any released $CO_2$ on pH at the Spirea Project site. Specifically, carbonate will act to buffer pH from changes due to $CO_2$ – with a carbonate concentration of even 1% by weight, pH changes are unlikely to be meaningful. Although carbonate aquifer matrix measurements in or near the AOR were not available, information provided by the project sponsor indicates that the primary injection zone is in the Lyons formation, which in some locations includes carbonates. There is one groundwater alkalinity[35] measurement in the vicinity of the AOR and it exceeds 200 mg/L, which suggests some potential for buffering capacity.

For USDW endangerment to occur from a CO2 release event that lowers aquifer pH, there also needs to be a sufficient reservoir of metals in the aquifer matrix to be leached into USDWs to result in health-based MCL exceedances. According to the project sponsor, concentrations of metals in the aquifer matrix in the AOI are not known.

With respect to potential pressure-induced brine migration into a USDW, halting or modifying injection activity until corrective action is taken (e.g., plugging/repairing a deep well that allowed brine to migrate to a USDW) can reduce subsurface pressure and limit the spatial extent/duration of potential impact. After injection is complete at the site the pressure front will dissipate over time, which also can limit the potential for USDW endangerment during the PISC period. Articles from the peer-reviewed technical literature identify additional factors that can limit potential impacts from brine migration. For example, Nicot et al., (2009) note that "owing simply to density differences due to temperature and salinity subsurface variations, a wellbore with a continuous open pathway between the injection formation and the bottom of the USDW will not necessarily lead to [brine] contamination of the USDW when CO2 is injected."[36] Nicot et al., also note that Minkoff et al., (2007) and Chang et al., (2008) showed that "thief" zone(s) between the USDW and injection formation "can attenuate significantly well bore pressure and absorb a significant fraction of the material flux."[37]

These factors support the reasonable assumption that, if a plume occurred in a USDW as a result of a release incident, that plume likely would be relatively modest in size. For example, analyses in relevant published literature generally describe radial $CO_2$ plume distances on the order of hundreds of meters or less.[38] Nevertheless, to estimate potential residential and irrigation impacts from a release incident associated with the Spirea Project, we conservatively assume that an impact plume could extend up to one mile from the release point and potentially endanger the aquifers currently used by local residents.

Specifically, an impact plume with a radius on the order of one mile from its center would affect an area roughly 3.14 square miles in size.[39] With respect to the potential number of residences that might be affected if a release event of that size were to occur in the Spirea Project AOR, our evaluation assumes impacts to a

[35] Alkalinity is a different measure of the capacity of water (or any solution) to neutralize or "buffer" acids.
[36] See Nicot, Jean-Philippe, Curtis M. Oldenburg, Steven L. Bryant and Susan D. Hovorka "Pressure perturbations from geologic carbon sequestration: Area of-review boundaries and borehole leakage driving forces" in Energy Procedia 1 (2009) 47-54.
[37] As cited in Nicot et al., (2009): S. E Minkoff,. S. L. Bryant, J.-P. Nicot, and C. M. Oldenburg, Modeling leakage of CO2 along a fault for risk assessment (abs.), in Sixth Annual Conference on Carbon Capture & Sequestration: Expediting deployment of industrial scale systems: Can it be done? How? Concerns to be addressed, May 7–10, Pittsburgh, Abstract #053, (2007) and K.W Chang, S. E. Minkoff and S. L. Bryant, Modeling Leakage through Faults of CO2 Stored in an Aquifer, SPE 115929, presented at 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.
[38] See for example Elizabeth Keating, D. Bacon, S. Carroll, K. Mansoor, Y. Sun, L Zheng, D. Harp and Z. Dai. Applicability of aquifer impact models to support decisions at CO2 sequestration sites. International Journal of Greenhouse Gas Control 52 (2016) 319-330. and Nicholas Huerta, D. Bacon, C. Carman and C. Brown. NRAP Toolkit Screening for CarbonSAFE Illinois – Macon County. Illinois State Geological Survey Prairie Research Institute and Pacific Northwest National Laboratory. Report prepared for US DOE 00029381. 2020.
[39] 3.14 square miles = $\pi$ * (1 mile radius)$^2$ = 3.14 * 1 square mile.

maximum of 12 households. As previously noted, satellite imagery (see Exhibit 1) shows that most of the AOR is highly rural, with a low density of scattered residences and a substantial amount of agriculture and ranching/livestock activity. As previously noted the AOR is approximately 34 square miles in size and includes approximately 88 domestic water wells, which implies an average density of about 2.6 domestic wells per square mile or about 8.1 domestic wells within a hypothetical release incident impact radius of 3.14 square miles.[40] Overall, publicly available information suggests an average residential density within the AOR that is well below the 12 residences per 3.14 square miles conservatively used in this analysis.

### 7.3 Cost Distribution for Endangerment to Human Health from Acute or Chronic Surface Release of CO2 Injectate

- Minimum: $0
- Median: $200,000
- 75th Percentile: 400,000
- Maximum: $1,800,000
- Bimodal distribution

We apply the above cost distribution to all incidents that involve a well, caprock, fault or pipeline release that occurs in a Monte Carlo trial.

There is a non-zero possibility that WWQR event-based risk activities may result in release incidents. Such incidents can create acute or chronic exposures to nearby residents necessitating emergency and remedial response. The maximum end of the cost distribution is based on the CO2 pipeline incident that occurred in Satartia, Mississippi in 2020.[41] It is generally accepted that this incident resulted in the most significant CO2-related public health impact to date.

The Satartia MS incident resulted in 45 hospitalizations. National Institute of Health (NIH) data suggests a 12-month treatment cost for 'unintentional suffocation or poisoning' at approximately $10,000 per person.[42] We believe that this estimate is reasonably conservative, and use it as the basis for the upper-bound (maximum) of the cost distribution. Importantly, the Satartia MS impacts occurred, in part, because a CO2 pipeline was located close to a small town. The town of Carpenter is located within the AOR of the Spirea Project, and has about twice the population of Satartia MS.[43] Because of Carpenter's relative size, we base the maximum health cost on an assumption of 90 hospitalizations (twice the number that occurred as a result of the Satartia incident).

In addition to treatment costs, we assume an additional $10,000 per person to address potential lost income and/or pain and suffering associated with a release incident that adversely impacts human health. Median per

[40] 8.1 wells (rounded) = (88 domestic water wells / 34 square mile AOI) * 3.14 square mile hypothetical contamination impact area with a radius of 1 mile from its center.
[41] US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Pipeline Safety Accident Investigation Division. Failure Investigation Report – Denbury Golf Coast Pipelines, LLC – Pipeline Rupture/Natural Force Damage. May 26, 2022. On February 22, 2020, Denbury's 24-inch Delhi Pipeline ruptured, releasing liquid CO2 that immediately began to vaporize at atmospheric conditions. The site of the rupture was approximately one mile southeast of Satartia, Mississippi. Denbury reported that the rupture released an estimated total of 31,405 barrels of CO2. Local authorities evacuated approximately 200 people near the rupture, including the entire town of Satartia (around 70 residents), and three homes across the Yazoo River. Forty-five people sought medical attention at local hospitals, including individuals who were caught in the vapor cloud while driving a vehicle. One individual was admitted to the hospital for reasons unrelated to the pipeline failure. There were no fatalities.
[42] Peterson, Cora, Likang Xu and Curtis Florence. Average medical cost of fatal and non-fatal injuries by type in the USA. Inj Prev. 2021 February ; 27(1): 24–33. doi:10.1136/injuryprev-2019-043544.
[43] The town of Spirea has a population of approximately 163 (compared to 73 for Satartia) according to American Community Survey 2021 5-year census data: https://censusreporter.org/profiles/16000US5612860-carpenter-wy/, https://censusreporter.org/profiles/16000US2865680-satartia-ms/

capita income for Wyoming residents is approximately $36,000.[44] We conservatively assume an average of one month's lost income for individuals affected by a pipeline release (i.e., $3,000 per person). We assign an additional $7,000 per-person (to arrive at the $10,000 included in the cost distribution) to address potential pain and suffering.[45] Given the likelihood that the potential impacts associated with CO2-related morbidity are likely to be relatively short-term, we believe $7,000 (about twice estimated lost income, and comparable to treatment costs) is reasonably conservative for purposes of deriving a financial assurance cost estimate.

Based on the information described above, we use a maximum cost estimate of $1,800,000.[46] We also include a minimum value of $0 in the cost distribution, because acute and chronic surface releases of CO2 injectate may have no human health impact. For example, in many circumstances, atmospheric dilution quickly reduces CO2 concentrations below relevant human health thresholds; there is diminished likelihood that, in this rural AOR with one (small) population center, people will be close enough to surface release locations to receive meaningful exposure; and implementation of the emergency response plan will help avoid impacts.

Readily available data indicate that public health impacts due to the transport and industrial use of CO2 are rare. A recent evaluation of PHMSA data identified 113 CO2 pipeline incidents that occurred between 1994 and 2021; to our knowledge, the Satartia, MS release is the only one that resulted in public health impacts.[47] Importantly, we have been unable to find documentation of any public health impacts arising from CO2 used in enhanced oil recovery operations or other industrial activities.

In light of this research we use a bimodal cost distribution to conservatively assume that 10% of subsurface or pipeline release events result in some level of human health impact. As a result, 90% of subsurface or pipeline release events are assigned $0 cost, because there no human health impacts expected to occur. For the remaining 10% of events, we assume a minimum cost of $20,000 (consistent with harm to one person) and a maximum cost of $1,800,000 (approximately twice the estimated treatment costs arising from the Satartia, MS pipeline incident).

Further, we assume a median cost of $200,000 and a 75$^{th}$ percentile cost of $400,000, approximately consistent with impacts to ten to twenty people, respectively. In our view, this cost distribution reasonably reflects the potentially exposed population, if an incident were to occur near a residence or small gathering in this highly rural area. Finally, we apply a Burr distribution to the cost range – while higher cost incidents potentially could occur, the AOR characteristics of the Spirea Project suggest that impacts to small numbers of people are substantially more likely than impacts to larger numbers of people.

### 7.4 Cost Distribution for Ecological and Response/Infrastructure Costs from Acute or Chronic Surface Release of CO2 Injectate

- Minimum: $5,000
- Maximum: $450,000
- Burr distribution

We apply the above cost distribution to all incidents that involve a well, caprock, fault or pipeline release incident that occur in a Monte Carlo trial.

This distribution is based on release-related cost information reported to the U.S. Department of Energy Pipeline and Hazardous Materials Safety Administration (PHMSA) for the 103 CO2 pipeline release incidents

[44] https://www.census.gov/quickfacts/WY.
[45] Pain and suffering amounts (if awarded) are difficult to forecast and depend largely on legal jurisdiction, case-specific circumstances, and other factors impossible to predict with any degree of certainty.
[46] $1,800,000 = 90 people impacted * ($10,000 per person treatment cost + $10,000 per person lost income/pain & suffering)
[47] Vitali, Matteo, C. Zuliani, F Corvaro, B Marchetti and F Tallone. Statistical Analysis of Incidents on Onshore CO2 Pipelines Based on PHMSA Database. Journal of Loss Prevention in the Process Industries 77 (2022) 104799.

recorded from 2002 through 2021. We believe that PHMSA offers the most reasonably conservative data for estimating costs associated with ecological response, and property and infrastructure damage, including changes to surface topography and structures, arising from acute or chronic surface releases of CO2 injectate.

Specifically, the Monte Carlo simulation includes PHMSA-identified costs arising from emergency response, environmental remediation and non-operator property damage due to release incidents. We do not include private-party costs, including, for example, the value of product lost or operator property damage, as these categories do not inform emergency and remedial response actions responsive to estimating financial assurance cost estimates for WWQR event-based risk activities.

Although PHMSA data indicate that most incidents resulted in relevant costs *less than* $5,000 per incident, we conservatively assign $5,000 as the cost distribution minimum. This cost estimate is intended to reflect minor incidents with minimal response-related activities.

We use $450,000 as the cost distribution maximum, which reflects the single incident with the highest cost in the PHMSA data; that is, the 2020 Sartartia, MS pipeline release. The total cost for this WWQR event-based risk activity is $431,361, which results from the afore-mentioned cost categories. We apply a Burr distribution to reflect the fact that pipeline release costs are skewed towards the lower end of the distribution – although higher costs can occur, they do so much less frequently than lower costs.

### 7.5 Cost Distribution for Mineral Rights Infringement

Data on Wyoming mineral rights are available from the state's Office of State Lands and Investments. We downloaded geospatial layers for active oil and gas and mineral rights and cross-referenced them with the AOR shapefile for the Spirea Project. This cross-reference revealed no active oil and gas leases and no active mineral leases within the 34 square mile AOR. As a result we do not believe that, for financial assurance cost estimation purposes, the potential for such costs is material for the Spirea Project.[48]

For completeness, if mineral activity were to occur in the AOR, it is reasonable to expect that it would continue at depths shallower than the subsurface confining layers above the CO2 storage plume. Conceptually, however, it is possible that a subsurface release event could temporarily interfere with mineral extraction operations that were planned or underway in subsurface areas near the release.

In the absence of actual mineral extraction activity in the AOR, the project sponsor may need to "refund" the equivalent of a lease payment to affected mineral rights holders, for an appropriate time period, in response to potentially temporarily interfering with the holder's ability to exercise their lease rights. But as noted above, readily available public information indicates that there are no active oil and gas or mineral leases in the AOR, and so to our knowledge there are no lease payments.

It is our understanding that Wyoming mineral leases typically reflect a five-year term, require a lease payment, and a royalty based on mineral production. Royalty payments data are not readily available, but presumably there are no such payments in the AOR due to the lack of active leases.

Finally, it is possible that active mineral operations could experience other types of losses from a WWQR risk-based event activity (e.g. lost profits, business interruption). At this time, given the lack of active mineral operation activity in the AOR, quantifying any such potential losses would be too speculative to result in a reasonable cost estimate.

[48] Although readily available, public information indicates that there are no active oil and gas or mineral leases in the AOR, the Monte Carlo model can apply a mineral rights infringement cost distribution to relevant incidents. To the extent new information becomes available with respect to oil and gas or mineral leases in the AOR, Monte Carlo calculations can be revised accordingly.

Per WWQR Chapter 24, Section 26(b), financial assurance cost estimates (including those that address emergency and remedial response associated with WWQR risk-based event activities like mineral rights infringement) must be updated annually, or within 60 days of receiving notice that the Administrator has determined that a demonstration of financial assurance is no longer adequate. Consistent with Section 25(a)(i) and (a)(ii) requirements, financial assurance cost estimates also will need to be reevaluated after any updates to the emergency and remedial response plan. Consistent with these regulatory requirements, to the extent actual mineral extraction activity in the AOR occurs during the life of the Spirea Project, the financial assurance cost estimates will be reevaluated.

### 7.6 Cost Distribution for Property and Infrastructure Damage Arising from Induced Seismicity

- Minimum: $0
- Median: $100,000
- 75$^{th}$ Percentile: $200,000
- Maximum: $500,000
- Burr distribution

We apply the above cost distribution to all induced seismic events that occur in a Monte Carlo trial.

To develop this cost distribution, we compiled a dataset of all parcels that intersect with the AOR by combining: 1) Wyoming Department of Revenue statewide property assessment and valuation data; 2) the shapefile of the Spirea Project AOR; and 3) a separately-accessed shapefile of all parcels in Laramie County. This data analysis yielded 217 individual parcels, as of tax year 2023.

The property value data for these parcels are summarized in Exhibit 5, including the value of land and any improvements made to the land (generally, structures). Exhibit 6 summarizes the same data set, but excludes land values.

In our view, an induced seismic event of the magnitude relevant to the Spirea Project (discussed further below) could adversely impact structures, but is not likely to result in adverse impact to the land, itself. We estimate there is approximately $20 million property infrastructure within the AOR that potentially could be adversely impacted by an induced seismic event.

As previously indicated, the project sponsor's seismicity evaluation found a 2% probability of exceedance in 50 years for seismic events ranging from 5% to almost 14% peak ground acceleration (in southeastern and northwestern Laramie County, respectively). For purposes of deriving a financial assurance cost estimate for emergency and remedial response related to this WWQR risk-based event activity, we converted peak ground acceleration numbers into a measure of possible monetary damage.

Exhibit 7 summarizes information from the United States Geological Survey (USGS) that relates peak ground acceleration to Modified Mercalli Intensity (MMI), a commonly referenced measure of earthquake intensity. The maximum peak ground acceleration of 14% estimated for the AOR corresponds to MMI category VI (which includes seismic events with peak ground accelerations between 9.2% and 18%).

The USGS also provides summary information describing the type of damage associated with different MMI categories (see Exhibit 8). As show in Exhibit 8, MMI Category VI events are associated with events "felt be all, many frightened, some heavy furniture moved, a few instances of fallen plaster. Damage slight." Relying on these representations, we assume a maximum repair cost equal to 2.5% of total structure value.

### Exhibit 5. Summary of Property Values for Parcels in the AOR

| Parcel Type | Count | Total Acreage | Average Acreage | Total Value ($) |
|---|---|---|---|---|
| Agricultural | 79 | 21,891 | 277 | $18,812,947 |
| Commercial | 8 | 11 | 1 | $332,674 |
| Commercial – Vacant Land | 2 | 0 | 0 | $6,455 |
| Industrial | 1 | 15 | 15 | $278,250 |
| Industrial – Vacant Land | 1 | 260 | 260 | $167,624 |
| Residential | 83 | 1,366 | 16 | $16,589,505 |
| Residential – Vacant Land | 37 | 1,520 | 41 | $2,256,524 |
| Exempt, w/ data | 6 | 3 | 0 | $16,655 |
| *Exempt, w/o data* | *7* | *34* | *5* | -- |
| *N/A (no data available)* | *1* | -- | -- | -- |
| **Total Parcels with Data** | **217** | **25,067** | **116** | **$38,460,634** |

Notes: From Laramie County, Wyoming geospatial data (https://maps.laramiecounty.com/arcgis/rest/services/features/CountyBaseMapFeatures/MapServer/2). Fields relied upon: "accttype" for parcel type; "netacres" for acreage; and "totalcostv" for value.

### Exhibit 6. Summary of Parcel Structure Values in the AOR

| Parcel Type | Count | No. w/ Improvements | Total Impr. Value |
|---|---|---|---|
| Agricultural | 79 | 29 | $5,058,996 |
| Commercial | 8 | 8 | $251,340 |
| Commercial – Vacant Land | 2 | 0 | -- |
| Industrial | 1 | 1 | $95,892 |
| Industrial – Vacant Land | 1 | 0 | -- |
| Residential | 83 | 79 | $13,853,033 |
| Residential – Vacant Land | 37 | 0 | -- |
| Exempt, w/ data | 6 | 0 | -- |
| *Exempt, w/o data* | *7* | *0* | -- |
| *N/A (no data available)* | *1* | *0* | -- |
| **Total Parcels with Data** | **217** | **117** | **$19,259,261** |

Notes: From Laramie County, Wyoming geospatial data (https://maps.laramiecounty.com/arcgis/rest/services/features/CountyBaseMapFeatures/MapServer/2). Fields relied upon: "accttype" for parcel type; "netacres" for acreage; "totalimpsv" for improvement value; and "totalcostv" for total (land plus improvement) value.

We believe this estimate is reasonably conservative and likely would be sufficient to address potential damage on the order of "a few instances of fallen plaster." To derive the maximum value for this cost distribution, we assume all structures in the AOR are impacted by a seismic event and require the maximum level of repair (i.e., 2.5% of total structure value). This assumption results in a cost distribution maximum of $500,000.[49] We use a minimum cost distribution value of $0, because induced seismic events can occur at low intensities with no attendant damage. We also assume a median distribution value of $100,000, generally consistent with an event that only impacts highly rural parts of the AOR (the vast majority of the AOR is highly rural, outside of

[49] $500,000 = $20 million total value of structures in the AOR * 2.5% maximum repair cost.

the small town of Carpenter on the eastern edge of the AOR). Finally, we assume a 75th percentile estimate of $200,000 and use a Burr distribution for this cost range.

**Exhibit 7. Modified Mercalli Intensity Relative to Peak Ground Acceleration, Perceived Shaking and Potential Damage***

| Modified Mercalli Intensity | Acceleration (%g) (PGA) | Perceived Shaking | Potential Damage |
|---|---|---|---|
| I | <0.17 | Not felt | None |
| II | 0.17 – 1.4 | Weak | None |
| III | 0.17 – 1.4 | Weak | None |
| IV | 1.4 – 3.9 | Light | None |
| V | 3.9 – 9.2 | Moderate | Very Light |
| VI | 9.2 – 18 | Strong | Light |
| VII | 18 – 34 | Very Strong | Moderate |
| VIII | 34 – 65 | Severe | Moderate to Heavy |
| IX | 65 – 124 | Violent | Heavy |
| X | >124 | Extreme | Very Heavy |
| XI | >124 | Extreme | Very Heavy |
| XII | >124 | Extreme | Very Heavy |

iles/EQ101.pdf.

**Exhibit 8. Damage Potential Associated with Different MMI Category Events***

| Intensity | Shaking | Description/Damage |
|---|---|---|
| I | Not felt | Not felt except by a very few under especially favorable conditions. |
| II | Weak | Felt only by a few persons at rest,especially on upper floors of buildings. |
| III | Weak | Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated. |
| IV | Light | Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. |
| V | Moderate | Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop. |
| VI | Strong | Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. |
| VII | Very strong | Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. |
| VIII | Severe | Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. |
| IX | Violent | Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. |
| X | Extreme | Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. |

*See, for example, https://www.usgs.gov/programs/earthquake-hazards/modified-mercalli-intensity-scale

Although analyses completed by the project sponsor suggest a potential peak ground acceleration of 14% for northwest Laramie County, the AOR is in the southeastern portion of the county; and, in fact, the AOR is associated with a lower peak ground acceleration of 5%. This intensity level is associated with MMI Category V, which, in turn, is associated with lower levels of damage ("felt by nearly everyone, many awakened, some dishes, windows broken, unstable objects overturned, pendulum clocks may stop").

Although higher costs (i.e., MMI category VI risk-based event across the entire AOR) could result (and conservatively are the basis used for induced seismicity cost calculations), we believe they are substantially

less likely to occur than lower cost events. Further, as previously noted, the project AOR has limited oil and gas development and lacks the extensive history of deep injection of fluids from nearby oil and gas operations that typically accompany areas experiencing significant induced seismicity.

### 7.7 Cost Distribution for Pore Space Trespass

- Minimum: $5,000
- Maximum: $650,000
- Uniform distribution

We apply the cost distribution above to all pore space trespass incidents that occur in a Monte Carlo trial.

As we understand, prior to initial CO2 injection, the project sponsor will have secured all necessary pore space, consistent with processes identified in the State of Wyoming regulations for unitization of geologic sequestration sites (WY § Stat 35-11-315 (2022)). Information provided by the project sponsor indicates that after initial CO2 injection, rights holders will share a lease payment expected to be approximately $1 per ton of CO2, divided among rights holders in proportion to their ownership (i.e., an owner contributing 1% of the area used for storage will receive 1% of the per-ton storage payments).[50]

Presently, the project sponsor forecasts storage of approximately 10.6 million tons of CO2 at the Spirea Project, resulting in total nominal per-ton payments for pore space storage rights of $10.6 million.[51] For purposes of deriving a financial assurance cost estimate, we assume that the per-ton payments will be made annually over the 17-year injection period, based on injected volumes evinced in the prior year.[52]

Per WWQR Chapter 24: Section 26(b)(i), financial assurance cost estimates must be in current dollars. We determine the present (current) value of the stream of nominal ($1 per ton) pore space payments, based on the operational life of the injection well that comprises the Spirea Project. We do so, using the present value method.[53] The calculations underpinning the present values summarized in Exhibit 9 are based on: 1) anticipated injection rate, as provided by the project sponsor; 2) the date that the Spirea injection well is anticipated to begin injection, 3) the length of time the well is anticipated to remain operational; and 4) annual discount rates aligned to future expected inflation rates[54] published by the Board of Governors of the U.S. Federal Reserve System as a measure of the rate at which prices are likely to change over the life of the injection well. As shown in Exhibit 9, factoring for the above assumptions, pore space rights payments total approximately $8.4 million (2023$).

Importantly, if pore space trespass were to occur, it is possible that no additional payments would be required. As we understand from the project sponsor, the payment amount initially negotiated with pore space rights holders and identified in a unitization agreement (anticipated to be $1 per ton) would remain unchanged, the total payment simply would be divided among a (larger) number of storage acres.

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[50] Some rights holders also will receive pre-injection payments, but such payments are not relevant to trespass cost estimation (which can only occur after injection begins).
[51] This total value is consistent with the project sponsor's representation of $1 per-ton of CO2 stored, divided among rights holders in proportion to ownership.
[52] The project sponsor has represented that such payments may be done quarterly instead of annually. The difference in the time value of money between quarterly and annually is de minimis.
[53] The present value method is used in corporate finance to determine today's value of a stream of future cash flows or payments. Present value analysis is based on the expectation that funds invested, today, can grow over time to match the expected need and timing for funds in the future. This concept is referred to as the Time Value of Money; that is, money available today is worth more than the same amount in the future, because of its potential to earn a return on investment.
[54] See Federal Reserve Bank of Cleveland, "Inflation Expectations" data series: "Expected Inflation and Real and Inflation Risk Premia" at https://www.clevelandfed.org/our-research/indicators-and-data/inflation-expectations.aspx (Nov. 2023).

**Exhibit 9. Pore Space Rights Payments Discounting Calculations**

| Well | Injection Start Date | Injection End Date | Total Injection Days | Total MMT | Present Value (2023$) |
|---|---|---|---|---|---|
| Spirea I-1 | 1/1/2025 | 1/1/2042 | 6,209 | 10,600,000 | $8,413,905 |

For purposes of financial assurance cost estimation, however, we conservatively assume that is not the case. Rather, we assume that an additional, supplemental payment would be required to pore space rights holders who were not part of the original unitization agreement, and who, subsequent to CO2 injection, experience trespass.

From a timing perspective, trespass is highly unlikely to occur during the early years of injection – in our view, trespass risk increases as the total volume of injection increases and more time is provided for the CO2 plume to move through the subsurface environment. For these reasons, and for purpose of financial assurance cost estimation, we make the reasonable, simplifying assumption that should any trespass occur it is likely to occur during the last 10 years of the project's 17 year injection period. At that time, should trespass occur, 'trespassed' pore space rights holders would be entitled to receive a per-acre payment comparable to that received by pore space rights holders who were subject to the initial unitization agreement and who received payments during the operational life of the well.[55]

Based on injection volume and the timing information provided by the project sponsor for each of the five injection wells in the AOR, pore space rights payments during the last 10 years of the project's injection period are expected to total approximately $4.6 million (2023$). We assume these payments would be allocated over an average area of about 15,000 acres, which implies a total pore space rights payment price of approximately $300/acre over the ten year 'trespass' period.[56] If, instead, the storage plume extended (and thereby trespassed) into an additional 2,150 acres (about 10% of the maximum anticipated plume size), that would result in a total maximum trespass payment of approximately $650,000.[57]

Based on the information and approach described above, we use 650,000 as the maximum for our potential trespass cost distribution. This estimate is conservative – as previously noted, the actual movement of CO2 in the subsurface environment will be calibrated with modeled predictions on a regular and systematic basis, and therefore it is likely that any potential trespass issue would be identified prior to occurrence and the amount and/or location of ongoing CO2 injection potentially adjusted to reduce or eliminate the trespass concern. In addition, if trespass occurs it is possible that no additional payments would be required (i.e., the storage rights per-injected-ton payment amount would remain unchanged, but divided among a (larger) number of storage acres). To the extent potential trespass begins later than assumed in our calculations, the present value (2023$) of storage rights payments would decrease.

Finally, for purposes of Monte Carlo analysis, we assume a minimum trespass payment of $5,000, which allows for the reasonable possibility of trespass across very small acreages. We apply a uniform distribution to the cost range, which results in an equal chance for selection of every cost within the range.

## 8.0 MONTE CARLO ANALYSIS RESULTS

Based on a model run of 50,000 Monte Carlo trials **we estimate an upper-bound financial assurance cost estimate to satisfy emergency and remedial response and WWQR event-based risk activities of $5.3**

[55] We focus on the injection period for these calculations, because pore space rights payments are expected to be made as CO2 is injected. Based on information provided by the project sponsor, no additional storage rights payments are expected during site closure or post-injection site care (PISC).
[56] $300 ($2023) per acre (rounded) = $4.6 million ($2023) pore space rights payments over last ten years of injection / 15,000 acres. The injectate plume will increase in size over time, up to a maximum (modeled plume plus buffer area) of approximately 21,500 acres.
[57] $650,000 (rounded) = $300 per acre * 2,150 acres trespassed

**million in current 2023 dollars.** This upper-bound cost estimate reflects the single Monte Carlo trial with the greatest financial assurance costs out of the 50,000 trials run (see Exhibit 10). We believe this estimate to be reasonable and appropriately conservative.

**Exhibit 10. ERR and Event-Based Risk Activity Financial Assurance Cost Estimation Results (2023$)**

| Summary Statistic | Cost | # of Events Occurring |
|---|---|---|
| Average | $200,681 | 0.45 |
| Standard Deviation | $443,031 | 0.67 |
| 5th Percentile | $0 | 0 |
| 50th Percentile | $0 | 0 |
| 95th Percentile | $1,274,390 | 2 |
| 99th Percentile | $1,923,872 | 2 |
| Minimum | $0 | 0 |
| Maximum | $5,248,291 | 5 |

Consistent with WWQR Chapter 24: Section 26(b)(iv) requirements, the Monte Carlo-based financial assurance cost estimates: incorporate cost curves shall combine risk probabilities, event outcomes, and damages assessment to calculate expected losses under a series of events; provide estimates of 50th, 95th, 99th percentile probabilities of occurrence; are calculated by project phase; are based on cost estimates that reflect third party-performance of response actions; and account for the entire Spirea Project AOR.

Exhibit 11 provides a summary of results by event and cost type. Across all 50,000 Monte Carlo trials, deep oil and gas well leaks accounted for the largest fraction of estimated costs (approximately 44.1%) followed by leakage through caprock/faults then shallow wells (30.5%), pore space trespass (16.2%), pipeline release (6.9%), induced seismicity (1.3%), CO2 injection well leak (0.19%) and slow leakage through caprock (0.77%). The types of costs addressed in these estimates include: well repair; USDW non-endangerment; release-related human health, ecological and infrastructure impacts; mineral rights infringement; pore space storage trespass; and, induced seismicity-related infrastructure damage.

**Exhibit 11. Cost Estimate Breakdown by Event and Cost Category Types**

| Event | Associated Cost Categories | Percent of Total Costs Across All Trials |
|---|---|---|
| Leakage Through Caprock/Faults then Shallow Well | Well repair (as applicable), USDW non-endangerment, release-related human health, ecological and infrastructure impacts, mineral rights infringement | 30.5% |
| Deep Oil & Gas Well Leak | | 44.1% |
| CO2 Injection Well Leak | | 0.19% |
| Slow Leakage Through Caprock | | 0.77% |
| Rapid Leakage Through Caprock | | 0.0% |
| Release Through Existing Faults | | 0.0% |
| Release Through Induced Faults | | 0.0% |
| Pipeline Release | Release-related human health, ecological and infrastructure impacts | 6.9% |
| Pore Space Trespass | Pore space storage rights payment | 16.2% |
| Induced Seismicity | Seismicity-related infrastructure damage | 1.3% |

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**Via Email**

November 27, 2023

EPA Region 8
1595 Wynkoop St
Denver, Colorado 80202

Re: Insurer Support – **Eastern Wyoming Sequestration Hub, Laramie County, WY**

To whom it may concern:

It is our pleasure to provide **High Plains Storage, LLC** insurance coverages to address project risks and meet their financial assurance responsibilities under the United States Environmental Protection Agency's Class VI Underground Injection Control regulations for the **High Plains Storage, LLC's Azalea I-1 Well Located in Laramie County** ("Project"). Marsh USA LLC, a subsidiary of Marsh McLennan, will approach carriers with AM Best ratings of A- or higher, and with size categories of VII or greater to secure bindable quotes for pollution insurance coverage. As a good faith measure of its commitment to the Class VI project, Tallgrass is providing a specimen policy with endorsements and a certificate. We will request quotes for policies conforming to these specimens with a limit of liability of $15 million as required by the Wyoming rule, but respectfully seek the opportunity to negotiate a pollution liability limit that reflects a risk-adjusted, conservative estimate of $9.4 million consistent with Wyoming cost estimation protocols as cited in the IEc's ERR/event-based risk activity analyses.

After receipt and satisfactory review of all the required underwriting data, Marsh USA LLC expects to bind the program and incept a Pollution Legal Liability insurance policy, with all applicable financial assurance endorsements attached, and the required certificate. Placing a Pollution Legal Liability policy requires an underwriting review to protect the carrier's exposure, as well as ensure that the programs they put in place (1) will comply with the Class VI Underground Injection Control regulations, and (2) protect human health and the environment - a goal enthusiastically shared by all parties involved in the Project. Marsh USA LLC and its carrier trading partners are committed to supporting the carbon capture & storage industry, and will work **High Plains Storage, LLC** to support the project with effective risk transfer and financial assurance.

Please do not hesitate to contact us with questions. We look forward to working with you.

Sincerely,

Matthew Kern
Senior Vice President
Marsh Environmental Practice

cc: Mark Webster

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**Senior Vice President**

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Denver, Colorado 80202

Re: Insurer Support – **Eastern Wyoming Sequestration Hub, Laramie County, WY**

To whom it may concern:

It is our pleasure to provide **High Plains Storage, LLC** insurance coverages to address project risks and meet their financial assurance responsibilities under the United States Environmental Protection Agency's Class VI Underground Injection Control regulations for the **High Plains Storage, LLC's Barberry I-1 Well Located in Laramie County** ("Project"). Marsh USA LLC, a subsidiary of Marsh McLennan, will approach carriers with AM Best ratings of A- or higher, and with size categories of VII or greater to secure bindable quotes for pollution insurance coverage. As a good faith measure of its commitment to the Class VI project, Tallgrass is providing a specimen policy with endorsements and a certificate. We will request quotes for policies conforming to these specimens with a limit of liability of $15 million as required by the Wyoming rule, but respectfully seek the opportunity to negotiate a pollution liability limit that reflects a risk-adjusted, conservative estimate of $9.4 million consistent with Wyoming cost estimation protocols as cited in the IEc's ERR/event-based risk activity analyses.

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Please do not hesitate to contact us with questions. We look forward to working with you.

Sincerely,

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November 27, 2023

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Denver, Colorado 80202

Re: Insurer Support – **Eastern Wyoming Sequestration Hub, Laramie County, WY**

To whom it may concern:

It is our pleasure to provide **High Plains Storage, LLC** insurance coverages to address project risks and meet their financial assurance responsibilities under the United States Environmental Protection Agency's Class VI Underground Injection Control regulations for the **High Plains Storage, LLC's Cypress I-1 Well Located in Laramie County** ("Project"). Marsh USA LLC, a subsidiary of Marsh McLennan, will approach carriers with AM Best ratings of A- or higher, and with size categories of VII or greater to secure bindable quotes for pollution insurance coverage. As a good faith measure of its commitment to the Class VI project, Tallgrass is providing a specimen policy with endorsements and a certificate. We will request quotes for policies conforming to these specimens with a limit of liability of $15 million as required by the Wyoming rule, but respectfully seek the opportunity to negotiate a pollution liability limit that reflects a risk-adjusted, conservative estimate of $9.4 million consistent with Wyoming cost estimation protocols as cited in the IEc's ERR/event-based risk activity analyses.

After receipt and satisfactory review of all the required underwriting data, Marsh USA LLC expects to bind the program and incept a Pollution Legal Liability insurance policy, with all applicable financial assurance endorsements attached, and the required certificate. Placing a Pollution Legal Liability policy requires an underwriting review to protect the carrier's exposure, as well as ensure that the programs they put in place (1) will comply with the Class VI Underground Injection Control regulations, and (2) protect human health and the environment - a goal enthusiastically shared by all parties involved in the Project. Marsh USA LLC and its carrier trading partners are committed to supporting the carbon capture & storage industry, and will work **High Plains Storage, LLC** to support the project with effective risk transfer and financial assurance.

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November 27, 2023

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Denver, Colorado 80202

Re: Insurer Support – **Eastern Wyoming Sequestration Hub, Laramie County, WY**

To whom it may concern:

It is our pleasure to provide **High Plains Storage, LLC** insurance coverages to address project risks and meet their financial assurance responsibilities under the United States Environmental Protection Agency's Class VI Underground Injection Control regulations for the **High Plains Storage, LLC's Juniper I-1 Well Located in Laramie County** ("Project"). Marsh USA LLC, a subsidiary of Marsh McLennan, will approach carriers with AM Best ratings of A- or higher, and with size categories of VII or greater to secure bindable quotes for pollution insurance coverage. As a good faith measure of its commitment to the Class VI project, Tallgrass is providing a specimen policy with endorsements and a certificate. We will request quotes for policies conforming to these specimens with a limit of liability of $15 million as required by the Wyoming rule, but respectfully seek the opportunity to negotiate a pollution liability limit that reflects a risk-adjusted, conservative estimate of $9.4 million consistent with Wyoming cost estimation protocols as cited in the IEc's ERR/event-based risk activity analyses.

After receipt and satisfactory review of all the required underwriting data, Marsh USA LLC expects to bind the program and incept a Pollution Legal Liability insurance policy, with all applicable financial assurance endorsements attached, and the required certificate. Placing a Pollution Legal Liability policy requires an underwriting review to protect the carrier's exposure, as well as ensure that the programs they put in place (1) will comply with the Class VI Underground Injection Control regulations, and (2) protect human health and the environment - a goal enthusiastically shared by all parties involved in the Project. Marsh USA LLC. and its carrier trading partners are committed to supporting the carbon capture & storage industry, and will work **High Plains Storage, LLC** to support the project with effective risk transfer and financial assurance.

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To whom it may concern:

It is our pleasure to provide **High Plains Storage, LLC** insurance coverages to address project risks and meet their financial assurance responsibilities under the United States Environmental Protection Agency's Class VI Underground Injection Control regulations for the **High Plains Storage, LLC's Old Barberry I1 Well Located in Laramie County** ("Project"). Marsh USA LLC, a subsidiary of Marsh McLennan, will approach carriers with AM Best ratings of A- or higher, and with size categories of VII or greater to secure bindable quotes for pollution insurance coverage. As a good faith measure of its commitment to the Class VI project, Tallgrass is providing a specimen policy with endorsements and a certificate. We will request quotes for policies conforming to these specimens with a limit of liability of $15 million as required by the Wyoming rule, but respectfully seek the opportunity to negotiate a pollution liability limit that reflects a risk-adjusted, conservative estimate of $9.4 million consistent with Wyoming cost estimation protocols as cited in the IEc's ERR/event-based risk activity analyses.

After receipt and satisfactory review of all the required underwriting data, Marsh USA LLC expects to bind the program and incept a Pollution Legal Liability insurance policy, with all applicable financial assurance endorsements attached, and the required certificate. Placing a Pollution Legal Liability policy requires an underwriting review to protect the carrier's exposure, as well as ensure that the programs they put in place (1) will comply with the Class VI Underground Injection Control regulations, and (2) protect human health and the environment - a goal enthusiastically shared by all parties involved in the Project. Marsh USA LLC and its carrier trading partners are committed to supporting the carbon capture & storage industry, and will work **High Plains Storage, LLC** to support the project with effective risk transfer and financial assurance.

Please do not hesitate to contact us with questions. We look forward to working with you.

Sincerely,

Matthew Kern
Senior Vice President
Marsh Environmental Practice

cc: Mark Webster

**Matthew Kern**
**Senior Vice President**

Marsh USA LLC
540 West Madison Street
Chicago, IL 60661-3630
+1 312 627 6181
www.marsh.com
matthew.kern@marsh.com

**Via Email**

November 27, 2023

EPA Region 8
1595 Wynkoop St
Denver, Colorado 80202

Re: Insurer Support – **Eastern Wyoming Sequestration Hub, Laramie County, WY**

To whom it may concern:

It is our pleasure to provide **High Plains Storage, LLC** insurance coverages to address project risks and meet their financial assurance responsibilities under the United States Environmental Protection Agency's Class VI Underground Injection Control regulations for the **High Plains Storage, LLC's Spirea I-1 Well Located in Laramie County** ("Project"). Marsh USA LLC, a subsidiary of Marsh McLennan, will approach carriers with AM Best ratings of A- or higher, and with size categories of VII or greater to secure bindable quotes for pollution insurance coverage. As a good faith measure of its commitment to the Class VI project, Tallgrass is providing a specimen policy with endorsements and a certificate. We will request quotes for policies conforming to these specimens with a limit of liability of $15 million as required by the Wyoming rule, but respectfully seek the opportunity to negotiate a pollution liability limit that reflects a risk-adjusted, conservative estimate of $9.4 million consistent with Wyoming cost estimation protocols as cited in the IEc's ERR/event-based risk activity analyses.

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Please do not hesitate to contact us with questions. We look forward to working with you.

Sincerely,

Matthew Kern
Senior Vice President
Marsh Environmental Practice

cc: Mark Webster

**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# CLAIM AND NOTICE REPORTING

This endorsement modifies insurance provided under the following:
PRIME POLLUTION LIABILITY COVERAGE FORM
PRIME PUMPER POLLUTION LIABILITY COVERAGE FORM
PRIME PLUS GENERAL LIABLITY AND POLLUTION LIABILITY COVERAGE FORM
PRIME CONTRACTORS POLLUTION LIABILITY COVERAGE FORM
EXCESS LIABILITY COVERAGE FORM

Subject to the claims and notice reporting provisions within the policy, claim and notice reports may be given in writing via:

**POSTAL SERVICE to:**
ASCOT Insurance Company
55 W. 46th Street, 26th Floor
New York, NY 10036

**E-MAIL to:**
Environmentalclaims@ascotgroup.com

or

**By phone:**
24 Hour Claims Reporting: 1-833-454-3023
24 Hour Emergency Response: 1-833-ER-ASCOT

# PRIME PUMPER POLLUTION LIABILITY

**(Pollution for Upstream, Midstream, Production, Exploration and Refining)**

## COVERAGE FORM

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# PRIME PUMPER POLLUTION LIABILITY

**(Pollution for Upstream, Midstream, Production, Exploration and Refining)**

# COVERAGE FORM

Various provisions in this policy restrict coverage. Please read the entire policy carefully to determine rights, duties and what is and is not covered.

**SECTION I – COVERAGES**, **Coverage A – Covered Location Pollution Liability** of this policy provide claims-made coverage.

Throughout this policy the words "you" and "your" refer to the Named Insured shown in the Declarations, and any other person or organization qualifying as a Named Insured under this policy. The words "we", "us" and "our" refer to the Company providing this insurance.

The word "insured" means any person or organization qualifying as such under **SECTION II – WHO IS AN INSURED**.

Defined terms, other than headings, appear in bold face type. Refer to **SECTION V - DEFINITIONS**.

**SECTION I – COVERAGES**

**Coverage A – Covered Location Pollution Liability**

**1. Insuring Agreement**

**a.** We will pay those sums that the insured becomes legally obligated to pay as damages because of **bodily injury**, **property damage** or **environmental damage** to which this insurance applies caused by or resulting from a **pollution event** on, at, under or migrating from a **covered location**. We will have the right and the duty to defend the insured against any **suit** seeking those damages. However, we will have no duty to defend the insured against any **suit** seeking damages for **bodily injury**, **property damage** or **environmental damage** to which this insurance does not apply. We may, at our discretion, investigate any **pollution event** and settle any **claim** or **suit** that may result. But:

**(1)** The amount we will pay for damages is limited as described in **Section III – LIMITS OF INSURANCE AND DEDUCTIBLE**; and

**(2)** Our right and duty to defend ends when we have used up the applicable limit of insurance in the payment of judgments, settlements, **clean-up costs** under **Coverage A** or costs under **Coverage C**.

No other obligation or liability to pay sums or perform acts or services is covered unless explicitly provided for under **SECTION I – SUPPLEMENTARY PAYMENTS**.

**b.** This insurance applies to **bodily injury**, **property damage** or **environmental damage** only if:

**(1)** The **bodily injury**, **property damage** or **environmental damage** is caused by or resulting from a **pollution event** that takes place in the **coverage territory**; and

**(2)** The **bodily injury**, **property damage** or **environmental damage** is caused by or resulting from a **pollution event** that occurs before the end of the **policy period**; and

**(3)** The insured first discovers the **pollution event** during the **policy period**. Discovery of a **pollution event** happens when a **responsible insured (i)** first becomes aware of the **pollution event**, **(ii)** reports the **pollution event** to us in writing during the **policy period** or any extended reporting period we provide under **SECTION IV – CONDITIONS**, Condition **9. Extended Reporting Period**, and **(iii)** promptly reports the **pollution event** to the appropriate governmental authority as required by **environmental law**; or

**(4)** A **claim** for damages because of **bodily injury**, **property damage** or **environmental damage** is first made against the insured and reported to us in writing during the **policy period** or any extended reporting period we provide under **SECTION IV – CONDITIONS**, Condition **9. Extended Reporting**

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**Period**. A **claim** received by the insured during the **policy period** and reported to us within 30 days after the end of the **policy period** will be considered to have been reported within the **policy period**.

**c.** If a **claim** is first made against an insured and reported to us during the **policy period**, and additional **claims** arising from the same, related or continuous **pollution event** are made against an insured and reported to us during the **policy period** or during the policy period of a subsequent policy issued by us to you providing coverage substantially the same as that provided by **Coverage A – Covered Location Pollution Liability** for **claims** first made against an insured and reported to us during the **policy period**, then all such **claims** shall be:

**(1)** Deemed to be one **claim**;

**(2)** Deemed to have been first made and reported during this **policy period** on the date the first of such **claims** was made and reported; and

**(3)** Subject to the Coverage A – Covered Location Pollution Liability Limit stated in the Declarations.

Coverage under this **Coverage A – Covered Location Pollution Liability** for such **claims** shall not apply, however, unless at the time such subsequent **claims** are first made and reported, you have maintained with us coverage substantially the same as this **Coverage A – Covered Location Pollution Liability** on a continuous, uninterrupted basis since the first such **claim** was made against an insured.

**d.** Damages because of **bodily injury** include damages claimed by any person or organization for care, loss of services or death resulting at any time from the **bodily injury**.

**2. Exclusions**

In addition to exclusions found in **SECTION I – COMMON EXCLUSIONS**, this insurance does not apply to:

**a. Damage to Mode of Transportation**

**Property damage** to any **mode of transportation** utilized during **transportation**. This exclusion does not apply to **claims** made by third-party carriers for such **property damage** arising from the insured's negligence.

**b. Change in Use**

**Clean-up costs** required by **environmental law** due to a change in zoning or permitted use of any **covered location** during the **policy period**.

However, this exclusion does not apply to a **non-owned location** or a **divested location**.

**c. Construction Activities**

**Environmental damage** caused by or resulting from **pollutants** or a **pollution event** discovered during **construction activities** at a **covered location**.

**d. Intrusive Investigation**

**Environmental damage** caused by or resulting from a **pollution event** discovered during **intrusive investigation** at a **covered location** during the **policy period**.

However, this exclusion does not apply to a **non-owned location**.

**e. Landfill or Impoundment**

Costs, charges and expenses, incurred to investigate, remove, dispose of, abate, contain, treat, neutralize, monitor or test contaminated soil or other media in a landfill cell or an impoundment.

However, this exclusion does not apply to a **non-owned location**.

**f. Prior Known Pollution Event**

**Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** or a **recognized environmental condition** known to a **responsible insured** prior to **(i)** the

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effective date of the **policy period** or **(ii)** the effective date of an Endorsement to this policy adding a **covered location**.

This exclusion does not apply if:

**(1)** The **pollution event** known to a **responsible insured** did not meet reporting requirements under **environmental law**;

**(2)** A No Further Action (NFA) or equivalent decision has been documented in writing in accordance with **environmental law** as respects the **pollution event** or **recognized environmental condition** giving rise to the **bodily injury**, **property damage** or **environmental damage**;

**(3)** We have been notified in writing of such **pollution event** giving rise to the **bodily injury**, **property damage** or **environmental damage** during the policy period of a policy previously issued by us to you; or

**(4)** The **pollution event** or **recognized environmental condition** giving rise to the **bodily injury**, **property damage** or **environmental damage** is specifically referenced, or identified on a Prior Known Pollution Event Exclusion Amendment Endorsement attached to this policy.

**Coverage B - Miscellaneous Pollution Liability**

**1. Insuring Agreement**

**a.** We will pay those sums that the insured becomes legally obligated to pay as damages, to which this insurance applies, because of:

**(1) Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** arising out of **your work** scheduled to this policy by Endorsement;

**(2) Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** during **transportation**; or

**(3) Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **time-element pollution event** on, at, under or migrating from a **newly acquired location**.

**b.** We will have the right and duty to defend the insured against any **suit** seeking those damages. However, we will have no duty to defend the insured against any **suit** seeking damages to which this insurance does not apply. We may, at our discretion, investigate any **pollution event** and settle any **claim** or **suit** that may result. But:

**(1)** The amount we will pay for damages is limited as described in **SECTION III - LIMITS OF INSURANCE AND DEDUCTIBLE**; and

**(2)** Our right and duty to defend ends when we have used up the applicable limits of insurance in the payment of judgments, settlements, **clean-up costs** under **Coverage A** or costs under **Coverage C**.

No other obligation or liability to pay sums or perform acts or services is covered unless explicitly provided for under **SECTION I – SUPPLEMENTARY PAYMENTS**.

**c.** This insurance applies to **bodily injury**, **property damage** or **environmental damage** only if:

**(1)** The **bodily injury**, **property damage** or **environmental damage** is caused by or resulting from a **pollution event** that takes place in the **coverage territory**;

**(2)** The **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** arising out of **your work** occurs during the **policy period**; and

**(3)** Prior to the **policy period**, no **responsible insured** knew that the **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** arising out of **your work** had occurred, in whole or in part. If any **responsible insured** knew, prior to the **policy period**, that the **bodily injury**, **property damage** or **environmental damage** occurred, then any continuation, change or resumption of such **bodily injury**, **property damage** or **environmental damage** during or after the **policy period** will be deemed to have been known prior to the **policy period**. However,

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this does not apply to any continuation, change or resumption of **environmental damage** arising out of **your work** performed after the effective date of the **policy period**;

**(4)** The **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** during **transportation** occurs before the end of the **policy period**; and

**(5)** No **claim** for such **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** during **transportation** was made against the insured prior to the effective date of the **policy period**;

**(6)** The **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **time-element pollution event** on, at under or migrating from a **newly acquired location** occurs during the **policy period**.

**d.** **Bodily injury**, **property damage** or **environmental damage** will be deemed to have been known to have occurred at the earliest time when any **responsible insured**:

**(1)** Reports all, or any part, of the **bodily injury, property damage** or **environmental damage** to us or any other insurer;

**(2)** Receives a **claim** or **suit** for damages because of the **bodily injury**, **property damage** or **environmental damage**; or

**(3)** Becomes aware by any other means that **bodily injury**, **property damage** or **environmental damage** has occurred or has begun to occur.

**e.** The following applies to progressive or indivisible **bodily injury**, **property damage** or **environmental damage**, including any continuation, change or resumption of such **bodily injury**, **property damage** or **environmental damage**, which takes place over a period of days, weeks, months or longer caused by continuous or repeated exposure to the same, related or continuous **pollution event**:

**(1)** Such **bodily injury**, **property damage** or **environmental damage** shall be deemed to have taken place only on the date of first exposure to such **pollution event**; or

**(2)** Such **bodily injury**, **property damage** or **environmental damage** shall be deemed to have taken place during the policy period of the first policy issued by us to you providing coverage substantially the same as that provided by **Coverage B – Miscellaneous Pollution Liability** of this policy for **bodily injury**, **property damage** or **environmental damage** that takes place during the **policy period** but only if:

**(a)** The date of first exposure cannot be determined or is before the effective date of the first policy issued by us to you providing coverage substantially the same as that provided by **Coverage B – Miscellaneous Pollution Liability** of this policy for **bodily injury**, **property damage** or **environmental damage** that takes place during the **policy period**; and

**(b)** Such **bodily injury**, **property damage** or **environmental damage** continues, in fact, to occur during this **policy period**.

**f.** If the same, related or continuous **pollution event** results in **bodily injury**, **property damage** or **environmental damage** that takes place during the policy periods of different policies issued by us to you providing coverage substantially the same as that provided by **Coverage B – Miscellaneous Pollution Liability** of this policy for **bodily injury**, **property damage** or **environmental damage** that takes place during the **policy period**:

**(1)** All such **bodily injury**, **property damage** and **environmental damage** shall be deemed to have taken place only during the first policy period of such policies in which any of the **bodily injury**, **property damage** or **environmental damage** took place; and

**(2)** All damages arising from all such **bodily injury**, **property damage** or **environmental damage** shall be deemed to have arisen from one **pollution event** and shall be subject to the Coverage B – Miscellaneous Pollution Liability Limit applicable to the policy for such first policy period.

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**g.** Damages because of **bodily injury** include damages claimed by any person or organization for care, loss of services or death resulting at any time from the **bodily injury**.

**2. Exclusions**

In addition to exclusions found in **SECTION I – COMMON EXCLUSIONS**, this insurance does not apply to:

**a. Covered Location Transportation**

**Environmental damage** caused by or resulting from a **pollution event** during **transportation** within the boundaries of a **covered location**.

**b. Damage to Mode of Transportation**

**Property damage** to any **mode of transportation** utilized during **transportation**. This exclusion does not apply to **claims** made by third-party carriers for such **property damage** arising from the insured's negligence.

**c. Damage to Your Work**

**Property damage** or **environmental damage** to that particular part of any property on which you are performing **your work** if the **property damage** or **environmental damage** arises out of **your work**.

This exclusion does not apply if the damaged work or the work out of which the damage arises was performed on your behalf by a subcontractor.

**d. Disposal Site**

**Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** on, at, under or migrating from any transfer, storage, disposal, landfill, treatment or consolidation **location** beyond the boundary of a job site where **your work** is performed.

**Coverage C - Emergency and Crisis Management Costs**

**1. Insuring Agreement**

**a.** We will pay **emergency costs** incurred by or on behalf of the insured in response to an imminent or substantial threat to human health or the environment caused by or resulting from a **pollution event**:

**(1)** Arising out of **your work**;

**(2)** During **transportation**; or

**(3)** On, at, under or migrating from a **covered location** or a **newly acquired location**.

**b.** But only if:

**(1)** The **pollution event** first commenced during the **policy period**;

**(2)** The **pollution event** takes place in the **coverage territory**;

**(3)** The **emergency costs**, except for **crisis management costs**, are incurred within ten business days of commencement of the **pollution event**; or

**(4)** The **crisis management costs** are incurred within six months of commencement of the **pollution event**; and

**(5)** The **pollution event** and related **emergency costs** are reported to us in writing within 30 business days of commencement of the **pollution event**.

**c.** We will pay these costs regardless of fault. But the amount we will pay is limited as described in **SECTION III - LIMITS OF INSURANCE AND DEDUCTIBLE**.

No other obligation or liability to pay sums or perform acts or services is covered unless explicitly provided for under **SECTION I – SUPPLEMENTARY PAYMENTS**.

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**2. Exclusions**

In addition to exclusions found in **SECTION I – COMMON EXCLUSIONS** and **Coverage A – Covered Location Pollution Liability**, this insurance does not apply to:

**a. Divested Location**

**Emergency costs** incurred as a result of a **pollution event** on, at, under or migrating from a **divested location**.

**b. Non-Owned Location**

**Emergency costs** incurred as a result of a **pollution event** on, at, under or migrating from a **non-owned location**.

**SECTION I – COMMON EXCLUSIONS**

The insurance provided in **SECTION I** does not apply to:

**1. Asbestos and Lead**

**Environmental damage** caused by, resulting from, arising out of or related to, in whole or in part, the actual, alleged, threatened or suspected presence or existence of asbestos, asbestos containing materials, lead or lead containing materials in, on, or applied to any building or other structure.

However, this exclusion does not apply to **environmental damage** to land, any **mode of transportation**, the atmosphere, any watercourse or body of water including surface water or groundwater.

**2. Closure Costs**

Any cost, charges and expenses for closure, post closure, reclamation or plug and abandonment of well activities or obligations.

**3. Contractual Liability**

**Bodily injury**, **property damage** or **environmental damage** for which the insured is obligated to pay damages by reason of the assumption of liability in a contract or agreement. This exclusion does not apply to liability for damages:

**a.** That the insured would have in the absence of the contract or agreement; or

**b.** Assumed in a contract or agreement that is an **insured contract**, provided the **bodily injury**, **property damage** or **environmental damage** occurs subsequent to the execution of the contract or agreement. Solely for the purposes of liability assumed in an **insured contract**, reasonable attorneys' fees and necessary litigation expenses incurred by or for a party other than an insured are deemed to be damages because of **bodily injury**, **property damage** or **environmental damage**, provided:

**(1)** Liability to such party for, or for the cost of, that party's defense has also been assumed in the same **insured contract**; and

**(2)** Such attorneys' fees and litigation expenses are for defense of that party against a civil or alternative dispute resolution proceeding in which damages to which this insurance applies are alleged.

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**4. Drilling and Specialty Equipment**

**Property damage** to drilling, work-over or servicing equipment.

**5. Employer's Liability**

**Bodily injury** to:

**a.** An **employee** of the insured arising out of and in the course of employment by the insured or performing duties related to the conduct of the insured's business; or

**b.** The spouse, child, parent, brother or sister of that **employee** as a consequence of Paragraph **a.** above.

This exclusion applies whether the insured may be liable as an employer or in any other capacity and to any obligation to share damages with or repay someone else who must pay damages because of the injury.

This exclusion does not apply to liability assumed by the insured under an **insured contract**.

**6. Expected or Intended Injury or Damage**

**Bodily injury**, **property damage** or **environmental damage** expected or intended from the standpoint of the insured.

However, this exclusion does not apply to **property damage** or **environmental damage** caused by or resulting from response to an imminent and substantial threat to human health or the environment.

**7. Noncompliance**

**Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **responsible insured's** intentional disregard of, or deliberate, knowing, willful or dishonest noncompliance with any **environmental law**.

However, this exclusion does not apply to **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **responsible insured's** knowing or willful noncompliance with any **environmental law** in response to an imminent and substantial threat to human health or the environment.

**8. Nuclear Material**

**Bodily injury**, **property damage** or **environmental damage** caused by, resulting from, arising out of or related to, in whole or in part, the radioactive, toxic or explosive properties of **nuclear material** but only if the insured is:

**a.** Required to maintain financial protection pursuant to the Atomic Energy Act of 1954;

**b.** Entitled to indemnity from the United States of America or any agency thereof; or

**c.** An insured under a nuclear energy liability policy issued by Nuclear Energy Liability Insurance Association, Mutual Atomic Energy Liability Underwriters, Nuclear Insurance Association of Canada or any of their successors, or would be an insured under any such policy but for its termination upon exhaustion of limits.

**9. Subsurface Storage of Natural Gas**

**Bodily injury**, **property damage** or **environmental damage** that results from or is associated with the storage of natural gas in an underground storage facility including but not limited to depleted reservoirs in oil and gas fields, aquifers, salt caverns, salt domes, hard-rock caverns and mines.

**10. Underground Storage Tanks**

**Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** originating from or arising out of an **underground storage tank** which is: **(i)** known to a **responsible insured** as of the effective date of the **policy period**; **(ii)** known to a **responsible insured** as of the date of acquisition or initial occupancy of a **newly acquired location**; **(iii)** known to a **responsible insured** as of the date a **covered location** is added by Endorsement during the **policy period**; or **(iv)** installed during the **policy period**.

This exclusion does not apply to an **underground storage tank** which has been:

**a.** Closed, abandoned in place or removed in accordance with all applicable **environmental laws**; or

**b.** Scheduled to this policy by Endorsement.

**11. Upgrades, Improvements or Installations**

Any costs, charges or expenses for upgrade to, improvement of, or installation of any control of:

**a.** Any personal property on a **covered location**; or

**b.** Processes on, within or under a **covered location**.

This exclusion applies even if such upgrade, improvement or installation is required by **environmental law**.

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**12. War**

**Bodily injury**, **property damage** or **environmental damage**, however caused, arising, directly or indirectly, out of:

**a.** War, including undeclared or civil war;

**b.** Warlike action by a military force, including action in hindering or defending against an actual or expected attack, by any government, sovereign or other authority using military personnel or other agents; or

**c.** Insurrection, rebellion, revolution, usurped power, or action taken by governmental authority in hindering or defending against any of these.

**13. Workers' Compensation and Similar Laws**

Any obligation of the insured under a workers' compensation, disability benefits or unemployment compensation law or any similar law.

**SECTION I – SUPPLEMENTARY PAYMENTS**

**1.** We will pay, with respect to any **claim** we investigate or settle, any **suit** against an insured we defend, or any **emergency costs** incurred by or on behalf of any insured:

**a.** All expenses we incur that are directly allocated to a particular **claim** or **suit**.

**b.** All attorneys' fees or attorneys' expenses incurred by the insured in connection with **emergency costs**.

**c.** All reasonable expenses incurred by the insured at our request to assist us in the investigation or defense of the **claim** or **suit**, including actual loss of earnings up to $500 a day because of time off from work.

**d.** All court costs taxed against the insured in the **suit**. However, these payments do not include attorneys' fees or attorneys' expenses taxed against the insured.

**e.** Prejudgment interest awarded against the insured on that part of the judgment we pay. If we make an offer to pay the applicable limit of insurance, we will not pay any prejudgment interest based on that period of time after the offer.

**f.** All interest on the full amount of any judgment that accrues after entry of the judgment and before we have paid, offered to pay, or deposited in court the part of the judgment that is within the applicable limit of insurance.

These payments will not reduce the limits of insurance.

**2.** If we defend an insured against a **suit** and an indemnitee of the insured is also named as a party to the **suit**, we will defend that indemnitee if all of the following conditions are met:

**a.** The **suit** against the indemnitee seeks damages for which the insured has assumed the liability of the indemnitee in a contract or agreement that is an **insured contract**;

**b.** This insurance applies to such liability assumed by the insured;

**c.** The obligation to defend, or the cost of the defense of, that indemnitee, has also been assumed by the insured in the same **insured contract**;

**d.** The allegations in the **suit** and the information we know about the **pollution event** are such that no conflict appears to exist between the interests of the insured and the interests of the indemnitee;

**e.** The indemnitee and the insured ask us to conduct and control the defense of the indemnitee against such **suit** and agree that we can assign the same counsel to defend the insured and the indemnitee; and

**f.** The indemnitee:

**(1)** Agrees in writing to:

**(a)** Cooperate with us in the investigation, settlement or defense of the **suit**;

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**(b)** Immediately send us copies of any demands, notices, summonses or legal papers received in connection with the **suit**;

**(c)** Notify any other insurer whose coverage is available to the indemnitee; and

**(d)** Cooperate with us with respect to coordinating other applicable insurance available to the indemnitee; and

**(2)** Provides us with written authorization to:

**(a)** Obtain records and other information related to the **suit**; and

**(b)** Conduct and control the defense of the indemnitee in such **suit**.

So long as the above conditions are met, attorneys' fees incurred by us in the defense of that indemnitee, necessary litigation expenses incurred by us and necessary litigation expenses incurred by the indemnitee at our request will be paid as **SECTION I – SUPPLEMENTARY PAYMENTS**. Notwithstanding the provisions of **SECTION I – COMMON EXCLUSIONS**, Exclusion **3. Contractual Liability**, Paragraph **b.**, such payments will not be deemed to be damages for **bodily injury**, **property damage** and **environmental damage** and will not reduce the limits of insurance.

Our obligation to defend an insured's indemnitee and to pay for attorneys' fees and necessary litigation expenses as **SECTION I – SUPPLEMENTARY PAYMENTS** ends when we have used up the applicable limit of insurance in the payment of judgments or settlements; or the conditions set forth above, or the terms of the agreement described in Paragraph **f.** above, are no longer met.

**SECTION II – WHO IS AN INSURED**

**1.** If you are designated in the Declarations as:

**a.** An individual, you and your spouse are insureds, but only with respect to the conduct of a business of which you are the sole owner.

**b.** A partnership or joint venture, you are an insured. Your members, your partners, and their spouses are also insureds, but only with respect to the conduct of your business.

**c.** A limited liability company, you are an insured. Your members are also insureds, but only with respect to the conduct of your business. Your managers are insureds, but only with respect to their duties as your managers.

**d.** An organization other than a partnership, joint venture or limited liability company, you are an insured. Your **executive officers** and directors are insureds, but only with respect to their duties as your officers or directors. Your stockholders are also insureds, but only with respect to their liability as stockholders.

**e.** A trust, you are an insured. Your trustees are also insureds, but only with respect to their duties as trustees.

**2.** Any subsidiary, associated, affiliated, allied or limited liability company or corporation, including subsidiaries thereof, over which you maintain ownership or majority interest as of the effective date of the **policy period** qualify as a Named Insured.

**3.** Any organization you newly acquire or form, other than a partnership, joint venture or limited liability company, and over which you maintain ownership or majority interest, will qualify as a Named Insured if there is no other similar insurance available to that organization. However, coverage under this policy does not apply to **bodily injury**, **property damage** or **environmental damage** that occurred before you acquired or formed the organization.

**4.** Each of the following is also an insured:

**a.** Your **volunteer workers** only while performing duties related to the conduct of your business, or your **employees**, other than either your **executive officers** (if you are an organization other than a partnership, joint venture or limited liability company) or your managers (if you are a limited liability company), but only for acts within the scope of their employment by you or while performing duties

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related to the conduct of your business. However, none of these **employees** or **volunteer workers** are insureds for:

**(1) Bodily injury**:

**(a)** To you, to your partners or members (if you are a partnership or joint venture) or to your members (if you are a limited liability company); or

**(b)** For which there is any obligation to share damages with or repay someone else who must pay damages because of the injury described in Paragraphs **(1)(a)** above.

**(2) Property damage** or **environmental damage** to property owned, occupied or used by, rented to, in the care, custody or control of, or over which physical control is being exercised for any purpose by you, any of your **employees**, **volunteer workers**, any partner or member (if you are a partnership or joint venture), or any member (if you are a limited liability company).

**b.** Any person (other than your **employee**), or any organization while acting as your real estate manager.

**c.** Any person or organization having proper temporary custody of your property if you die, but only with respect to liability arising out of the maintenance or use of that property and until your legal representative has been appointed.

**d.** Your legal representative if you die, but only with respect to duties as such. That representative will have all your rights and duties under this policy.

**e.** Any person(s) or organization(s) for whom you have agreed in writing in a contract, agreement or permit that such person(s) or organization(s) be added as an additional insured on your policy. Such person(s) or organization(s) is an additional insured only with respect to liability for **bodily injury**, **property damage** or **environmental damage** caused, in whole or in part, by:

**(1)** Your acts or omissions or the acts or omissions of those acting on your behalf in connection with a **covered location** or **newly acquired location**;

**(2) Your work**;

**(3)** Your ownership, maintenance, operation or use of a **covered location** or **newly acquired location**.

However, the insurance afforded to such additional insured only applies to the extent permitted by law and will not be broader than that which you are required by the contract, agreement or permit to provide for such additional insured.

**f.** Any owner, co-owner, party of joint venture, mining partner or limited liability company having a non-operating working interest in any oil or gas lease of which you are the operator, but only with respect to their liability for **bodily injury**, **property damage** or **environmental damage** arising out of such non-operating working interest.

**g.** Any person or organization that has a controlling interest in you, but only with respect to their liability for **bodily injury**, **property damage** or **environmental damage** arising out of their financial control of you.

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**SECTION III – LIMITS OF INSURANCE AND DEDUCTIBLE**

**1.** The Limits of Insurance shown in the Declarations and the rules below fix the most we will pay regardless of the number of:

**a.** Insureds;

**b. Claims** made or **suits** brought;

**c.** Persons or organizations making **claims** or bringing **suits**; or

**d. Pollution events**.

**2.** The Policy Aggregate Limit is the most we will pay for the sum of all damages, **clean-up costs** and **emergency costs** under **Coverages A** through **C** inclusive.

**3.** Subject to Paragraph **2.** above, the Coverage A - Covered Location Pollution Liability Limit is the most we will pay for the sum of all damages and **clean-up costs** under **Coverage A - Covered Location Pollution Liability** because of all **bodily injury**, **property damage** and **environmental damage** caused by or resulting from the same, related or continuous **pollution event**.

**4.** Subject to Paragraph **2.** above, the Coverage B - Miscellaneous Pollution Liability Limit is the most we will pay for the sum of all damages under **Coverage B - Miscellaneous Pollution Liability** because of all **bodily injury, property damage** and **environmental damage** caused by or resulting from the same, related or continuous **pollution event**.

**5.** Subject to Paragraph **2.** Above, the Coverage C - Emergency and Crisis Management Costs Limit is the most we will pay under **Coverage C - Emergency and Crisis Management Costs** for the sum of all **emergency costs** incurred arising from the same, related or continuous **pollution event**.

**6.** The Limits of Insurance apply in excess of the Deductible amounts shown in the Declarations. The deductible amount applies as follows:

**a.** As respects Coverage A - Covered Location Pollution Liability Limit, to the sum of all damages and **clean-up costs** and any payments made under **SECTION I – SUPPLEMENTARY PAYMENTS** because of **bodily injury**, **property damage** or **environmental damage** caused by or resulting from the same, related or continuous **pollution event**.

**b.** As respects Coverage B - Miscellaneous Pollution Liability Limit, to the sum of all damages and any payments made under **SECTION I – SUPPLEMENTARY PAYMENTS** because of **bodily injury**, **property damage** or **environmental damage** caused by or resulting from the same, related or continuous **pollution event**.

**c.** As respects Coverage C – Emergency and Crisis Management Costs Limit, to the sum of all **emergency costs** incurred and any payments made under **SECTION I – SUPPLEMENTARY PAYMENTS** arising from the same, related or continuous **pollution event**.

However, if this insurance applies on an excess basis as described in **SECTION IV – CONDITIONS**, Condition **14. Other Insurance**, Paragraph **b. Excess Insurance**, the Deductible amounts shown in the Declarations will be eroded by any such valid and collectible other insurance.

We may pay any part or the entire deductible amount to effect settlement of any **claim** or **suit** or to pay **clean-up costs** or **emergency costs** which may be covered under this policy and, upon notification of the action taken, you shall promptly reimburse us for such part of the deductible amount as has been paid by us.

If the same or related **pollution event** results in coverage under more than one Coverage Part, only the highest deductible under any one Coverage Part will apply.

**7.** The Limits of Insurance apply to the entire **policy period**. If the **policy period** is extended after policy issuance for an additional period, the additional period will be deemed part of the last preceding period for the purposes of determining the Limits of Insurance.

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**SECTION IV – CONDITIONS**

**1. Bankruptcy**

Bankruptcy or insolvency of the insured or of the insured's estate will not relieve us of our obligations under this policy.

**2. Cancellation**

**a.** The first Named Insured shown in the Declarations may cancel this policy by mailing or delivering to us advance written notice of cancellation.

**b.** We may cancel this policy by mailing or delivering to the first Named Insured written notice of cancellation at least:

**(1)** Ten days before the effective date of cancellation if we cancel for nonpayment of premium; or

**(2)** Ninety days before the effective date of cancellation if we cancel for any other reason.

**c.** We will mail or deliver our notice to the first Named Insured's last mailing address known to us.

**d.** Notice of cancellation will state the effective date of cancellation. The **policy period** will end on that date.

**e.** If this policy is cancelled, we will send the first Named Insured any premium refund due. If we cancel, the refund will be pro rata. If the first Named Insured cancels, the refund will be less than pro rata and will be subject to the minimum earned premium stated in the Declarations. The cancellation will be effective even if we have not made or offered a refund.

**f.** If notice is mailed, proof of mailing will be sufficient proof of notice.

**3. Changes**

This policy contains all the agreements between you and us concerning the insurance afforded. The first Named Insured shown in the Declarations is authorized to make changes in the terms of this policy with our consent. This policy's terms can be amended or waived only by endorsement issued by us and made a part of this policy.

**4. Choice of Forum**

In the event that the insured and we have any dispute concerning or relating to this policy, including its formation, coverage provided hereunder, or the meaning, interpretation or operation of any term, condition, definition or provision of this policy resulting in litigation, arbitration or other form of dispute resolution, the insured agrees with us that any such litigation, arbitration or other form of dispute resolution shall take place in the appropriate federal or state courts located in New York, New York.

**5. Choice of Law**

In the event that the insured and we have any dispute concerning or relating to this policy, including its formation, coverage provided hereunder, or the meaning, interpretation or operation of any term, condition, definition or provision of this policy resulting in litigation, arbitration or other form of dispute resolution, the insured agrees with us that the internal laws of the State of New York shall apply without giving effect to any conflicts or choice of law principles. The terms and conditions of this policy shall not be deemed to constitute a contract of adhesion and shall not be construed in favor of or against any party hereto by reason or authorship or otherwise.

**6. Currency**

All reimbursement shall be made in United States currency at the rate of exchange prevailing on the date of judgment if judgment is rendered, the date of settlement if settlement is agreed upon with our written consent or the date of payment of **clean-up costs** and **emergency costs**, whichever is applicable.

**7. Duties in the Event of a Pollution Event, Claim or Suit**

**a.** Without limiting the requirements of any insuring agreement in this policy, you must see to it that we are notified as soon as practicable of a **pollution event** which may result in a **claim** or is reasonably likely to involve this policy. To the extent possible, notice should include:

**(1)** How, when and where the **pollution event** took place;

**(2)** The names and addresses of any injured persons and witnesses; and

**(3)** The nature and location of any injury or damage arising out of the **pollution event**.

**b.** If a **claim** is made or **suit** is brought against any insured, you must:

**(1)** Immediately record the specifics of the **claim** or **suit** and the date received; and

**(2)** Notify us as soon as practicable.

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You must see to it that we receive written notice of the **claim** or **suit** as soon as practicable.

**c.** You and any other involved insured must:

**(1)** Immediately send us copies of any demands, notices, summonses or legal papers received in connection with the **claim** or **suit**;

**(2)** Immediately send us copies of contracts, certificates of insurance, environmental site assessments and any other documents deemed pertinent by us to the **claim** or **suit**;

**(3)** Authorize us to obtain records and other information;

**(4)** Cooperate with us in the investigation or settlement of the **claim** or defense against the **suit**; and

**(5)** Assist us, upon our request, in the enforcement of any right against any person or organization which may be liable to the insured because of injury or damage to which this insurance may also apply.

**d.** In the event **emergency costs** are incurred, you must provide, in writing, all available information relating to such **emergency costs** and the **pollution event** giving rise thereto to us within 30 days of commencement of the pollution event.

**e.** In the event of a **time-element pollution event**, you must provide, in writing, all available information relating to the **pollution event** giving rise thereto to us within 30 days of commencement of the **pollution event**.

**f.** No insured will, except at that insured's own cost, voluntarily make a payment, assume any obligation, or incur any expense, other than **emergency costs**, without our consent.

**g.** When any insured becomes legally obligated to pay **clean-up costs** to which this insurance applies, the insured must:

**(1)** Submit, for our approval, all proposed work plans prior to submittal to any regulatory agency.

**(2)** Submit, for our approval, all bids and contracts for **clean-up costs** prior to execution or issuance.

**(3)** Forward progress submittals regarding **clean-up costs** at reasonable intervals and always prior to submittal to any regulatory agency that is authorized to review and approve such submittals.

We shall have the right, but not the duty, to assume direct control of such **clean-up costs**. Any **clean-up costs** incurred by us shall be applied against the applicable Limit of Insurance and deductible.

**h.** If we are prohibited under applicable law from investigating, defending or settling any such **claim** or **suit,** the insured shall, under our supervision, arrange for such investigation and defense thereof as is reasonably necessary, and subject to our prior authorization, shall effect such settlement thereof.

**8. Economic and Trade Sanctions**

In accordance with laws and regulation of the United States concerning economic and trade sanctions administered and enforced by The Office of Foreign Assets Control (OFAC), this policy is void ab initio solely with respect to any term or condition of this policy that violates any laws or regulations of the United States concerning economic and trade sanctions.

**9. Extended Reporting Period**

This condition applies only as respects **Coverage A – Covered Location Pollution Liability**.

**a.** This condition applies only if:

**(1)** The policy is cancelled or non-renewed for any reason except non-payment of the premium; or

**(2)** We renew or replace this policy with **Coverage A – Covered Location Pollution Liability** that provides claims-made coverage for **bodily injury**, **property damage** or **environmental damage** and that has a Retroactive Date; and

**(3)** You do not purchase coverage to replace the coverage described in Paragraph **a.(2)** above.

**b.** Automatic Extended Reporting Period

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You shall automatically have a period of 90 days following the effective date of such termination of coverage in which to provide written notice to us of **claims** first made and reported within the automatic extended reporting period.

A **claim** first made and reported within the automatic extended reporting period will be deemed to have been made on the last day of the **policy period**, provided that the **claim** is for damages or **clean-up costs** arising from a **pollution event** which commenced before the end of the **policy period** and is otherwise covered by this policy.

No part of the automatic extended reporting period shall apply if the optional extended reporting period is purchased.

**c.** Extended Reporting Period Option:

**(1)** A **claim** first made and reported within 48 months after the end of the **policy period** will be deemed to have been made on the last day of the **policy period**, provided that the **claim** is for damages or **clean-up costs** arising from a **pollution event** which commenced before the end of the **policy period** and is otherwise covered by this policy.

**(2)** The Extended Reporting Period Endorsement will not reinstate or increase the Limits of Insurance or extend the **policy period**.

**d.** We will issue the Endorsement indicating the Extended Reporting Period Option has been accepted if the first Named Insured shown in the Declarations:

**(1)** Makes a written request for it within 30 days after the end of the **policy period**; and

**(2)** Promptly pays the additional premium, which will not exceed 200% of the policy premium, when due.

The Extended Reporting Period Endorsement will not take effect unless the additional premium is paid when due. If that premium is paid when due, the Endorsement may not be cancelled. The additional premium will be fully earned when the Endorsement takes effect.

**e.** The Extended Reporting Period Endorsement will also amend **SECTION IV – CONDITIONS**, Condition **14. Other Insurance** so the insurance provided will be excess over any other valid and collectible insurance available to the insured, whether primary, excess, contingent or on any other basis, whose policy period begins or continues after the Endorsement takes effect.

**10. First Named Insured Duties**

The first Named Insured shown in the Declarations:

**a.** Is responsible for the payment of all premiums;

**b.** Will act on behalf of all other Named Insureds for giving and receiving of notice of cancellation;

**c.** Will be the payee for any return premiums that may become payable.

**11. Independent Counsel**

In the event the insured is entitled by law to select independent counsel to oversee our defense of a **claim** or **suit** at our expense, the attorney fees and all other litigation expenses we must pay to that counsel are limited to the rates we actually pay to counsel we retain in the ordinary course of business in the defense of similar **claims** or **suits** in the community where the **claim** or **suit** arose or is being defended.

Additionally, we may exercise the right to require that such counsel have certain minimum qualifications with respect to their competency including experience in defending **claims** or **suits** similar to the one pending against the insured and to require such counsel have a specific minimum amount of errors and omissions insurance coverage. As respects any such counsel, the insured agrees that counsel will timely respond to our request for information regarding the **claims** or **suit**.

Furthermore, the insured may at any time, by the insured's written consent, freely and fully waive these rights to select independent counsel.

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**12. Inspections and Surveys**

**a.** We have the right but not the duty to make inspections and surveys at any time, report on the conditions we find and recommend changes.

**b.** We are not obligated to make any inspections, surveys, reports or recommendations and any such actions we do undertake relate only to insurability and the premiums to be charged. We do not make safety inspections. We do not undertake to perform the duty of any person or organization to provide for the health or safety of workers or the public. We do not warrant that conditions are safe, healthful or comply with laws, regulations, codes or standards.

This applies not only to us, but also to any rating, advisory, rate service or similar organization which makes insurance inspections, surveys, reports or recommendations.

**13. Legal Action Against Us**

No person or organization has a right under this policy:

**a.** To join us as a party or otherwise bring us into a **suit** asking for damages from an insured; or

**b.** To sue us on this policy unless all of its terms have been fully complied with.

A person or organization may sue us to recover on an agreed settlement or on a final judgment against an insured; but we will not be liable for damages that are not payable under the terms of this policy or that are in excess of the applicable limit of insurance. An agreed settlement means a settlement and release of liability signed by us, the insured and the claimant or the claimant's legal representative.

**14. Other Insurance**

If other valid and collectible insurance is available to the insured for a loss we cover under this policy, our obligations are limited as follows:

**a. Primary Insurance**

This insurance is primary except when Paragraph **b.** below applies. If this insurance is primary, our obligations are not affected unless any of the other insurance is also primary. Then, we will share with all that other insurance by the method described in Paragraph **c.** below. However, regardless of whether **b.** below applies, in the event that a written contract or agreement or permit requires this insurance to be primary for any person or organization you agreed to insure and such person or organization is an insured under this policy, we will not seek contributions from any such other insurance issued to such person or organization.

**b. Excess Insurance**

**(1)** This insurance is excess over:

**(a)** Any other insurance, whether primary, excess, contingent or on any other basis that covers your liability for **bodily injury**, **property damage** or **environmental damage** arising from a **pollution event**;

**(b)** Any other insurance, whether primary, excess, contingent or on any other basis, available to you covering liability for damages caused by or resulting from a **pollution event** during **transportation**;

**(c)** Any other insurance, whether primary, excess, contingent or on any other basis, available to you covering liability for damages at a **covered location**, for which you have been added as an additional insured; or

**(d)** Any project specific primary insurance available to you covering liability for damages arising out of **your work**, for which you are an insured.

**(2)** When this insurance is excess, we will have no duty to defend the insured against any **suit** if any other insurer has a duty to defend the insured against that **suit**. If no other insurer defends, we will undertake to do so, but we will be entitled to the insured's rights against all those other insurers.

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**(3)** When this insurance is excess over other insurance, we will pay only our share of the amount of the loss, if any, that exceeds the sum of:

**(a)** The total amount that all such other insurance would pay for the loss in the absence of this insurance; and

**(b)** The total of all deductible and self-insured amounts under all that other insurance; and

**(c)** The Deductible amounts shown in the Declarations of this policy less the total amount pay in Paragraph **(a)** above.

**(4)** We will share the remaining loss, if any, with any other insurance that is not described in this Excess Insurance provision and was not bought specifically to apply in excess of the Limits of Insurance shown in the Declarations of this policy.

**c. Method of Sharing**

If other insurance is also primary, then we will share with all that other insurance by an equal share contribution method. Under this approach each insurer contributes equal amounts, excess of applicable deductible and self-insured amounts under all such insurance, until it has paid its applicable limit of insurance or none of the loss remains, whichever comes first.

**15. Representations**

By accepting this policy, you agree:

**a.** The statements in the Declarations are accurate and complete;

**b.** Those statements are based upon representations you made to us; and

**c.** We have issued this policy in reliance upon your representations.

**16. Separation of Insureds**

Except with respect to the Limits of Insurance and any rights or duties specifically assigned in this policy to the first Named Insured, this insurance applies:

**a.** As if each Named Insured were the only Named Insured; and

**b.** Separately to each insured against whom **claim** is made or **suit** is brought.

**17. Service of Suit**

It is hereby understood and agreed that we may be sued upon any cause of action arising under any insurance contract made by us or evidence of insurance issued or delivered by the broker, in the courts for the county(s) where the insurance provides coverage or in the courts of New York, New York where we maintain our home office.

It is further agreed that service of process in such suit may be made upon the Superintendent, Commissioner, Director of Insurance or other appropriate person at the state Department of Insurance, Secretary of State or other designee as provided for in specific state laws and/or regulations.

When service of process is made upon a statutory designee according to state law, such process should be provided via certified mail to us to the attention of our General Counsel.

It is further agreed that in any **suit** instituted against any insured under this policy or otherwise upon this policy, we will abide by the final decision of such court or of any appellate court in the event of an appeal.

**18. Transfer of Rights of Recovery Against Others to Us**

If the insured has rights to recover all or part of any payment we have made under this policy, those rights are transferred to us. The insured must do nothing after loss to impair them. At our request, the insured will bring **suit** or transfer those rights to us and help us enforce them. However, if the insured has waived rights of recovery against any person or organization, in writing, prior to a loss, we waive any right of recovery we may have under this policy against such person or organization.

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**19. Transfer of Your Rights and Duties Under This Policy**

Your rights and duties under this policy may not be transferred until we consent by Endorsement to the policy, except in the case of death of an individual named insured.

If you die, your rights and duties will be transferred to your legal representative but only while acting within the scope of duties as your legal representative. Until your legal representative is appointed, anyone having proper temporary custody of your property will have your rights and duties but only with respect to that property.

**20. When We Do Not Renew**

If we decide not to renew, we will mail or deliver to the first Named Insured shown in the Declarations written notice of the nonrenewal not less than 90 days before the expiration date. If notice is mailed, proof of mailing will be sufficient proof of notice.

**SECTION V – DEFINITIONS**

1. **Auto** means:
   - **a.** A land motor vehicle, trailer or semitrailer designed for travel on public roads, including any attached machinery or equipment; or
   - **b.** Any other land vehicle that is subject to a compulsory or financial responsibility law where it is licensed or principally garaged.
2. **Bodily injury** means physical injury, sickness, disease, building-related illness, mental anguish, shock or emotional distress, sustained by a person, including death resulting from any of these at any time. **Bodily injury** shall also include medical monitoring costs.
3. **Claim** means a written or verbal demand, notice or assertion of a legal right alleging liability or responsibility on the part of the insured.
4. **Clean-up costs** means reasonable costs, charges and expenses, incurred to investigate, remove, dispose of, abate, contain, treat, neutralize, monitor or test contaminated soil, surface water, groundwater, air or other media but only:
   - **a.** To the extent required by **environmental law**;
   - **b.** As respects **mold matter**, to the extent recommended in writing by an indoor environmental professional that we deem acceptable;
   - **c.** To the extent incurred by the government or any political subdivision within Definition **6.a**. **Coverage territory**; or
   - **d.** To the extent incurred by parties other than you.

   **Clean-up costs** includes **restoration costs**.
5. **Construction activities** means interior demolition, remodeling or renovation or subsurface excavation at a refinery or terminal.
6. **Coverage territory** means:
   - **a.** The United States of America (including its territories and possessions), Puerto Rico, Canada and the Gulf of Mexico; or
   - **b.** All other parts of the world if the injury or damage is caused by or results from a **pollution event**:
     - **(1)** On, at, under or migrating from a **non-owned location** or a scheduled **covered location** located in all other parts of the world;
     - **(2)** Arising out of **your work**; or
     - **(3)** During **transportation**.

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However, we assume no responsibility for furnishing certificates or evidence of insurance or bonds and we will not be liable for any fine or penalty imposed on you for failing to comply with insurance laws.

7. **Covered location** means:

   **a.** Any **location** you own, occupy, lease pursuant to terms of an oil & gas mineral lease or access pursuant to an easement or license agreement as of the effective date of the **policy period**;

   **b.** Any **location** in which you have a non-operating working interest pursuant to a Joint Operating Agreement as of the inception of the **policy period**;

   **c.** A **non-owned location**;

   **d.** A **divested location**; and

   **e.** Any **location** added by Endorsement to this policy.

8. **Crisis management costs** means reasonable costs, charges and expenses incurred for services provided by a crisis management firm that we deem acceptable. However, **crisis management costs** do not include compensation, fees, benefits, overhead charges or expenses of the insured.

9. **Divested location** means any **location** you cease to own, occupy, lease pursuant to terms of an oil and gas lease, access pursuant to an easement or license agreement or have a non-operating working interest pursuant to a Joint Operating Agreement during the **policy period** or any policy period of a policy previously issued by us to you providing coverage substantially the same as that provided by **SECTION I – COVERAGES** of this policy.

10. **Emergency costs** means reasonable costs, charges and expenses incurred to investigate, remove, dispose of, abate, contain, treat, neutralize, monitor or test contaminated soil, surface water, groundwater, air or other media.

    **Emergency costs** include **crisis management costs**.

11. **Employee** includes a **leased worker** and a **temporary worker**.

12. **Environmental damage** means physical damage to land, any **mode of transportation**, structures on land or water, the atmosphere, any watercourse or body of water including surface water or groundwater, giving rise to **clean-up costs**.

    **Environmental damage** does not include **property damage**.

13. **Environmental law** means any federal, state, provincial, municipal or local laws, including, but not limited to, statutes, rules, ordinances, guidance documents, regulations and all amendments thereto, including state voluntary cleanup or risk based corrective action guidance, and governmental, judicial or administrative orders and directives that are applicable to a **pollution event.**

14. **Executive officer** means a person holding any of the officer positions created by your charter, constitution, by-laws or any other similar governing document.

15. **Insured contract** means:

    **a.** A Joint Operating Agreement;

    **b.** A contract for a lease of premises;

    **c.** A sidetrack agreement;

    **d.** Any easement or license agreement;

    **e.** An obligation, as required by ordinance, to indemnify a municipality, except in connection with work for a municipality;

    **f.** An elevator maintenance agreement;

    **g.** That part of any other contract or agreement pertaining to your business (including an indemnification of a municipality in connection with work performed for a municipality) under which you assume the tort

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liability of another party to pay for **bodily injury**, **property damage** or **environmental damage** to a third person or organization. Tort liability means a liability that would be imposed by law in the absence of any contract or agreement.

Paragraph **g.** does not include that part of any contract or agreement that indemnifies an architect, engineer or surveyor for injury or damage arising out of:

**(1)** Preparing, approving, or failing to prepare or approve, maps, shop drawings, opinions, reports, surveys, field orders, change orders or drawings and specifications; or

**(2)** Giving directions or instructions, or failing to give them, if that is the primary cause of the injury or damage.

16. **Intrusive investigation** means the collection of original samples of soil, surface water or groundwater to analyze for quantitative values of various contaminants, performed for one or more of the following reasons:
    **a.** Contemplation of purchase or purchase by a person or entity other than you;
    **b.** Change in capital structure or ownership requiring **intrusive investigation**;
    **c.** Your noncompulsory desire to understand **environmental damage**;
    **d.** State specific Property Transfer Act requirements.
17. **Leased worker** means a person leased to you by a labor leasing firm under an agreement between you and the labor leasing firm, to perform duties related to the conduct of your business. **Leased worker** does not include a **temporary worker**.
18. **Location** means:
    **a.** Premises involving the same or connected lots;
    **b.** Premises whose connection is interrupted only by a street, roadway, waterway or right-of-way of a railroad;
    **c.** Real property contained within an easement.

    **Location** includes pooled units.
19. **Misdelivery** means the delivery of any liquid product into a wrong receptacle or to a wrong address or the erroneous delivery of one liquid product for another.
20. **Mode of transportation** means an **auto**, railcar, rolling stock, train, watercraft or aircraft. **Mode of transportation** does not include pipelines.
21. **Mold matter** means mold, mildew and fungi, whether or not such **mold matter** is living.
22. **Natural resource damage** means physical injury to or destruction of, as well as the assessment of such injury or destruction, including the resulting loss of value of land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.)), any state, local or provincial government, any foreign government, any Native American tribe, or, if such resources are subject to a trust restriction on alienation, any member of a Native American tribe.
23. **Newly acquired location** means any **location** that:
    **a.** You begin ownership or occupancy of after the effective date of the **policy period**; or
    **b.** You enter into a lease agreement pursuant to terms of an oil and gas mineral lease, an easement or license agreement or a non-operating working interest pursuant to a Joint Operating Agreement after the effective date of the **policy period**.

    However, coverage does not apply to **bodily injury**, **property damage** or **environmental damage** that occurred before you began ownership or occupancy or entered into any agreements in **b.** above.

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A **newly acquired location** does not include a **location** which is specifically scheduled as a **covered location**.

24. **Non-owned location** means any **location** performing operations or services on your behalf provided that the **location** is not, and never was, owned by, occupied by, loaned to, leased pursuant to terms of an oil and gas lease or accessed pursuant to an easement or license agreement by any insured. A **non-owned location** shall also include any job site location leased, rented, occupied or borrowed for use as a staging area to facilitate **your work**.

    **Non-owned location** does not include:

    **a.** Any **location** which any insured has or had a non-operating working interest pursuant to a Joint Operating Agreement.

    **b.** Any **location** which is not licensed by the appropriate federal, state or local authority to perform storage, disposal, processing or treatment of waste from your operations or **your work** in compliance with **environmental law**.

    **c.** Any **location** or any part thereof that has been listed or proposed to be listed on the Federal National Priorities list (NPL) or a state specific superfund site list prior to waste from your operations or **your work** being legally consigned for delivery or delivered for storage, disposal, processing or treatment at such **location**.

    **d.** Any **location** of a purchaser or user of **your product**.

25. **Nuclear material** means source material, special nuclear material or byproduct material which have the meanings given them in the Atomic Energy Act of 1954 or in any law amendatory thereof.

26. **Policy period** means the period of time stated in the Declarations. However, if the policy is cancelled in accordance with **SECTION IV – CONDITIONS**, Condition **2. Cancellation**, the **policy period** ends on the effective date of such cancellation.

27. **Pollutants** means any solid, liquid, gaseous or thermal irritant, or contaminant, including smoke, soot, vapor, fumes, acids, alkalis, chemicals, hazardous substances, hazardous materials, or waste materials, including medical, infectious and pathological wastes. **Pollutants** includes electromagnetic fields, **mold matter** and legionella pneumophila.

28. **Pollution event** means:

    **a.** The discharge, dispersal, release, escape, migration, or seepage of **pollutants** on, in, into, or upon land, any **mode of transportation**, structures on land or water, the atmosphere, any watercourse or body of water including surface water or groundwater; or

    **b.** The presence of **mold matter**; or

    **c.** **Misdelivery**.

    **Pollution event** includes the illicit abandonment of **pollutants** at any **location** which is owned or occupied by you provided that such abandonment was committed by parties other than an insured and without the knowledge of a **responsible insured**.

    **Pollution event** includes a **time-element pollution event**.

29. **Property damage** means:

    **a.** Physical injury to or destruction of tangible property, including all resulting loss of use and diminished value of that property. All such loss of use and diminished value shall be deemed to occur at the time of the physical injury that caused it;

    **b.** Loss of use and diminished value of tangible property that is not physically injured or destroyed. All such loss of use shall be deemed to occur at the time of the **occurrence** or **pollution event** that caused it; or

    **c.** **Natural resource damage**.

    **Property damage** does not include **environmental damage**.

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For the purpose of this insurance, electronic data is not tangible property. As used in this definition, electronic data means information, facts or programs stored as or on, created or used on, or transmitted to or from computer software, including systems and applications software, hard or floppy disks, CDROMS, tapes, drives, cells, data processing devices or any other media which are used with electronically controlled equipment.

30. **Recognized environmental condition** means a recognized environmental condition (REC) identified in a Phase I Environmental Site Assessment identifying the presence or likely presence of a hazardous substance or petroleum product indicative of:
    - **a.** An existing **pollution event**;
    - **b.** A past **pollution event**; or
    - **c.** A material threat of a future **pollution event**.
31. **Responsible insured** means:
    - **a.** Your **executive officers**, directors, partners or members;
    - **b.** Your manager of a **covered location** or **newly acquired location**;
    - **c.** Your **employee** responsible for environmental affairs, health and safety affairs, control or compliance or any other **employee** authorized by you to give or receive notice of a **claim**.
32. **Restoration costs** means reasonable and necessary costs incurred by the insured, to repair, restore or replace damaged real or personal property damaged during work performed in the course of incurring **clean-up costs** in order to restore the property to the condition it was in prior to being damaged during such work. **Restoration costs** shall not exceed the lesser of actual cash value of such real or personal property or the cost of repairing, restoring or replacing the damaged property with other property of like kind and quality. An adjustment for depreciation and physical condition shall be made in determining actual cash value. If a repair or replacement results in better than like kind or quality, we will not pay for the amount of the betterment, except to the extent such betterments of the damaged property entail the use of materials which are environmentally preferable to those materials which comprised the damaged property. Such environmentally preferable material must be certified as such by an applicable independent certifying body, where such certification is available, or, in the absence of such certification, based on our judgment in our sole discretion.
33. **Suit** means a civil proceeding in which damages to which this insurance applies are alleged. **Suit** includes an arbitration proceeding in which such damages are claimed and to which the insured must submit or does submit with our consent or any other alternative dispute resolution proceeding in which such damages are claimed and to which the insured submits with our consent.
34. **Temporary worker** means a person who is furnished to you to substitute for a permanent worker on leave or to meet seasonal or short-term workload conditions.
35. **Time-element pollution event** means a **pollution event** which:
    - **a.** First commences during the **policy period**;
    - **b.** Is first discovered by the insured within ten business days of commencement;
    - **c.** Is reported to us in writing within 30 business days of commencement; and
    - **d.** Does not originate or arise from an **underground storage tank**.
36. **Transportation** means the movement of goods, product, merchandise, supplies or waste in a **mode of transportation** by the insured or a third-party carrier from the time of movement from the point of origin until delivery to the final destination. **Transportation** includes the movement of goods, products, merchandise, supplies or waste into, onto or from a **mode of transportation**.
37. **Underground storage tank** means any tank, including any piping and appurtenances connected to the tank, located on or under a **covered location** or a **newly acquired location**, that has at least 10% of its combined volume underground. **Underground storage tank** does not include:

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**a.** Septic tanks, sump pumps, or oil/water separators;

**b.** A tank that is enclosed within a basement or cellar, if the tank is upon or above the surface of the floor; or

**c.** Storm-water or wastewater collection systems.

**38. Volunteer worker** means a person who is not your **employee**, and who donates his or her work and acts at the direction of and within the scope of duties determined by you, and is not paid a fee, salary or other compensation by you or anyone else for their work performed for you.

**39. Your product**:

**a.** Means:

**(1)** Any goods or products, other than real property, manufactured, sold, handled, distributed or disposed of by:

**(a)** You;

**(b)** Others trading under your name; or

**(c)** A person or organization whose business or assets you have acquired; and

**(2)** Containers (other than vehicles), materials, parts or equipment furnished in connection with such goods or products.

**b.** Includes:

**(1)** Warranties or representations made at any time with respect to the fitness, quality, durability, performance or use of **your product**; and

**(2)** The providing of or failure to provide warnings or instructions.

**40. Your work** means work or operations performed by you or on your behalf scheduled by Endorsement to this policy.



**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# CONSTRUCTION ACTIVITIES EXCLUSION DELETION

This endorsement modifies insurance provided under the following:
PRIME PUMPER POLLUTION LIABILITY COVERAGE

It is hereby agreed that the policy to which this Endorsement is attached is amended as follows:

**SECTION I – COVERAGES**, **Coverage A – Covered Location Pollution Liability**, Paragraph **2. Exclusions**, Exclusion **c. Construction Activities** is deleted in its entirety.




ALL OTHER TERMS, CONDITIONS AND EXCLUSIONS OF THIS POLICY REMAIN UNCHANGED.

**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# DESIGNATED COVERED LOCATION LIMITATION

This endorsement modifies insurance provided under the following:
PRIME PUMPER POLLUTION LIABILITY COVERAGE FORM

It is hereby agreed that the policy to which this Endorsement is attached is amended as follows:

**A. SECTION V – DEFINITIONS**, Definition **7. Covered location** is deleted and replaced with the following:

**7. Covered location** means the **location(s)** designated in the Schedule below and any **non-owned location** utilized by a **covered location** for the disposal of your waste generated and transported solely from that **covered location**.

**B. SECTION I – COVERAGES**, **Coverage B – Miscellaneous Pollution Liability**, Paragraph **1. Insuring Agreement**, Subparagraph **a.** is deleted and replaced with the following:

**a.** We will pay those sums that the insured becomes legally obligated to pay as damages, to which this insurance applies, because of:

**(1) Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** arising out of **your work** scheduled to this policy by Endorsement; or

**(2) Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** during **transportation** to or from a **covered location**.

**C. SECTION I – COVERAGES**, **Coverage C – Emergency and Crisis Management Costs**, Paragraph **1. Insuring Agreement**, Subparagraph **a.** is deleted and replaced with the following:

**a.** We will pay **emergency costs** incurred by or on behalf of the insured in response to an imminent or substantial threat to human health or the environment caused by or resulting from a **pollution event**:

**(1)** Arising out of **your work**;

**(2)** During **transportation** to or from a **covered location**; or

**(3)** On, at, under or migrating from a **covered location**.

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**SCHEDULE OF DESIGNATED COVERED LOCATION(S):**

| WELL DESCRIPTION |
| --- |
| |

**WELL DESCRIPTION**

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ALL OTHER TERMS, CONDITIONS AND EXCLUSIONS OF THIS POLICY REMAIN UNCHANGED.

**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# SUBSURFACE STORAGE OF NATURAL GAS EXCLUSION DELETION

This endorsement modifies insurance provided under the following:
PRIME PUMPER POLLUTION LIABILITY FORM

It is hereby agreed that the policy to which this Endorsement is attached is amended as follows:

**SECTION I – COMMON EXCLUSIONS**, Exclusion **9. Subsurface Storage of Natural Gas** is deleted in its entirety.

ALL OTHER TERMS, CONDITIONS AND EXCLUSIONS OF THIS POLICY REMAIN UNCHANGED.

**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# FINANCIAL RESPONSIBILITY – UNDERGROUND INJECTION CONTROL PROGRAM – CLASS VI

This endorsement modifies insurance provided under the following:
PRIME PUMPER POLLUTION LIABILITY COVERAGE FORM

It is hereby agreed that the policy to which this Endorsement is attached is amended as follows:

Solely as respects the **covered location(s)** identified in the Schedule of this Endorsement and the insured's obligation to demonstrate financial responsibility under the United States Environmental Protection Agency, Chapter I – Environmental Protection Agency, Subchapter D – Water Programs, Part 146 – Underground Injection Control Program: Criteria and Standards, Subpart H – Criteria and Standards Applicable to Class VI Wells, Section 40 CFR § 146.85, it is hereby agreed:

**SCHEDULE:**

| **Covered Location: Facility Name and Mailing Address** | **Covered Location:** | **Permit Number:** |
|---|---|---|
| | | |

**LIMITS of INSURANCE:**

| | |
|---|---|
| **Financial Responsibility Each Event Limit** | TBD |
| **Financial Responsibility Aggregate Limit** | TBD |

**A. SECTION III – LIMITS OF INSURANCE AND DEDUCTIBLE** is amended to include the following:

The Financial Responsibility Each Event Limit shown in the Schedule of this Endorsement is the most we will pay for the sum of all damages and **clean-up costs** under **SECTION I – COVERAGES, Coverage A – Covered Location Pollution Liability** because of **bodily injury, property damage** or **environmental damage** caused by or resulting from the same, related or continuous **pollution event** at a **covered location** shown in the Schedule.

The Financial Responsibility Aggregate Limit shown in the Schedule of this Endorsement is the most we will pay for the sum of all damages and **clean-up costs** under **SECTION I – COVERAGES, Covered Location Pollution Liability**, **Coverage A – Covered Location Pollution Liability**.

**B. SECTION IV – CONDITIONS** is amended to include the following:

We agree to furnish the Regional Administrator of the USEPA a signed duplicate original of the policy and all endorsements when requested.

**C. SECTION IV – CONDITIONS**, Condition **3. Cancellation** is deleted in its entirety and replaced with the following:

**2. Cancellation**

**a.** We may cancel this policy only for nonpayment of premium. In such event, we will mail or deliver to the first Named Insured and the Regional Administrator of the USEPA, by certified mail, written notice of cancellation at least 120 days before the effective date of cancellation.

**b.** We will mail or deliver our notice to the first Named Insured's last mailing address known to us.

**c.** Notice of cancellation will state the effective date of cancellation. The **policy period** will end on that date.




ALL OTHER TERMS, CONDITIONS AND EXCLUSIONS OF THIS POLICY REMAIN UNCHANGED.

**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# PRIOR KNOWN POLLUTION EVENT EXCLUSION AMENDMENT

This endorsement modifies insurance provided under the following:
PRIME PUMPER POLLUTION LIABILITY COVERAGE FORM

It is hereby agreed that the policy to which this Endorsement is attached is amended as follows:

**SECTION I – COVERAGES**, **Coverage A – Covered Location Pollution Liability**, Paragraph **2. Exclusions**, Exclusion **f. Prior Known Pollution Event** is deleted and replaced with the following:

**f. Prior Known Pollution Event**

**Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** or a **recognized environmental condition** known to a **responsible insured** prior to **(i)** the effective date of the **policy period (ii)** the effective date of an Endorsement to this policy adding a **covered location** or **(iii)** the acquisition or initial occupancy date of a **newly acquired location**.

This exclusion does not apply if:

**(1)** The **pollution event** known to a **responsible insured** did not meet reporting requirements under **environmental law**. However, if no reporting requirements exist for such known **pollution event** then this exception does not apply;

**(2)** The presence of **mold matter** known to a **responsible insured** has been remediated to the extent recommended in writing by an indoor environmental professional that we deem acceptable;

**(3)** A No Further Action (NFA) or equivalent decision has been documented in writing in accordance with **environmental law** as respects the **pollution event** or **recognized environmental condition** giving rise to the **bodily injury**, **property damage** or **environmental damage**;

**(4)** We have been notified in writing of such **pollution event** giving rise to the **bodily injury**, **property damage** or **environmental damage** during the policy period of a policy previously issued by us to you; or

**(5)** The **pollution event** or **recognized environmental condition** giving rise to the **bodily injury**, **property damage** or **environmental damage** is identified in the Schedule below:

**SCHEDULE:**

None Scheduled

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ALL OTHER TERMS, CONDITIONS AND EXCLUSIONS OF THIS POLICY REMAIN UNCHANGED.

# CERTIFICATE OF INSURANCE

Name and Address of Insured: _____

Name and Address of Insurer: _____

Policy Amount: _____

Policy Number: _____

Effective Date: _____

Certification:

Ascot Specialty Insurance Company, the Insurer, as identified above, hereby certifies that it has issued liability insurance covering the following Injection Well(s):

| Name | Address | Identification No. |
|---|---|---|

Ascot Specialty Insurance Company, the Insurer, hereby certifies that it has issued to the Insured the policy of insurance identified above to provide financial assurance for emergency and remedial response for the injection wells identified above. The Insurer further warrants that such policy conforms in all respects with the requirements for the fulfillment of emergency and remedial response obligations as described by 40 CFR §146.94 as applicable and as such regulations were constituted on the date shown below. It is agreed that any provision of the policy inconsistent with such regulations is hereby amended to eliminate such inconsistency.

The Insurer may cancel the policy only for failure to pay the premium and by sending notice of cancellation by certified mail to the owner or operator and to the Director for the area in which the injection well is located. The EPA requires that cancellation not become final for 120 days beginning on the date of receipt of the notice of cancellation by the Director, as evidence by the return receipts.

Whenever requested by the Director, the Insurer agrees to furnish to the Director a duplicate original of the policy listed above, including all endorsements.

[Signature of an authorized representative of Insured]

[Name]

[Title], [Authorized Representative of Ascot Specialty Insurance Company]

[Address of Representative]

[Signature of Witness or Notary]

[Date]

Berkley Surety
a Berkley Company

November 17, 2023

**Re:** Tallgrass Energy, LP- CCS Wyoming Project

To Whom it May Concern:

It has been the privilege of Berkley Insurance Company ("Berkley Surety")[1] and/or its underwriting team to consider providing a surety bond for Tallgrass Energy, LP for the CCS Wyoming Project. At their request we will give favorable consideration to providing the required bonds.

Please note that the decision to issue surety bonds is a matter between Tallgrass Energy, LP and Berkley Surety, and will be subject to our standard underwriting at the time of the final bond request, which will include but not be limited to the acceptability of the contract documents, bond forms and financing. We assume no liability to third parties or to you if for any reason we do not execute said bonds.

Berkley Surety is "Treasury Listed" by the U. S. Department of the Treasury with an underwriting limitation expressed therein of over $717,168,000. The A.M. Best Company has assigned Berkley Surety a rating of "A+". Berkley Surety is fully licensed and authorized to write bonds of this size and type in the State of Wyoming. If you have any questions or need any additional information, please do not hesitate to contact me.

Sincerely,
Berkley Insurance Company






Hillary D. Shepard
Attorney-in-Fact

Berkley Surety
a Berkley Company

1250 E Diehl Rd Ste 200, Naperville, IL 60563
Phone: 630.210.0360 Fax: 630.210.0377

**No. BI-1345r-el**

POWER OF ATTORNEY
**BERKLEY INSURANCE COMPANY**
WILMINGTON, DELAWARE

KNOW ALL MEN BY THESE PRESENTS, that BERKLEY INSURANCE COMPANY (the "Company"), a corporation duly organized and existing under the laws of the State of Delaware, having its principal office in Greenwich, CT, has made, constituted and appointed, and does by these presents make, constitute and appoint: ***Patrick T. Pribyl; Debra J. Scarborough; Mary T. Flanigan; Jeffrey C. Carey; Christy M. Braile; Charissa D. Lecuyer; Evan D. Sizemore; Charles R. Teter, III; Rebecca S. Leal; C. Stephens Griggs; Tahitia M. Fry; Kellie A. Meyer; Veronica Lawver; Lauren Scott; Hillary D. Shepard; Erin C. Lavin; Kristin D. Thurber; or Danielle R. Capps of Lockton Companies, LLC of Kansas City, MO*** its true and lawful Attorney-in-Fact, to sign its name as surety only as delineated below and to execute, seal, acknowledge and deliver any and all bonds and undertakings, with the exception of Financial Guaranty Insurance, providing that no single obligation shall exceed **Fifty Million and 00/100 U.S. Dollars (U.S.$50,000,000.00),** to the same extent as if such bonds had been duly executed and acknowledged by the regularly elected officers of the Company at its principal office in their own proper persons.

This Power of Attorney shall be construed and enforced in accordance with, and governed by, the laws of the State of Delaware, without giving effect to the principles of conflicts of laws thereof. This Power of Attorney is granted pursuant to the following resolutions which were duly and validly adopted at a meeting of the Board of Directors of the Company held on January 25, 2010:

**RESOLVED**, that, with respect to the Surety business written by Berkley Surety, the Chairman of the Board, Chief Executive Officer, President or any Vice President of the Company, in conjunction with the Secretary or any Assistant Secretary are hereby authorized to execute powers of attorney authorizing and qualifying the attorney-in-fact named therein to execute bonds, undertakings, recognizances, or other suretyship obligations on behalf of the Company, and to affix the corporate seal of the Company to powers of attorney executed pursuant hereto; and said officers may remove any such attorney-in-fact and revoke any power of attorney previously granted; and further

**RESOLVED**, that such power of attorney limits the acts of those named therein to the bonds, undertakings, recognizances, or other suretyship obligations specifically named therein, and they have no authority to bind the Company except in the manner and to the extent therein stated; and further

**RESOLVED**, that such power of attorney revokes all previous powers issued on behalf of the attorney-in-fact named; and further

**RESOLVED**, that the signature of any authorized officer and the seal of the Company may be affixed by facsimile to any power of attorney or certification thereof authorizing the execution and delivery of any bond, undertaking, recognizance, or other suretyship obligation of the Company; and such signature and seal when so used shall have the same force and effect as though manually affixed. The Company may continue to use for the purposes herein stated the facsimile signature of any person or persons who shall have been such officer or officers of the Company, notwithstanding the fact that they may have ceased to be such at the time when such instruments shall be issued.

IN WITNESS WHEREOF, the Company has caused these presents to be signed and attested by its appropriate officers and its corporate seal hereunto affixed this 20th day of April, 2023.

BERKLEY INSURANCE COMPANY CORPORATE SEAL 1975 DELAWARE

Attest:

By _____
Ira S. Lederman
Executive Vice President & Secretary

Berkley Insurance Company

By _____
Jeffrey M. Hafter
Senior Vice President

STATE OF CONNECTICUT )
) ss:
COUNTY OF FAIRFIELD )

Sworn to before me, a Notary Public in the State of Connecticut, this 20th day of April, 2023, by Ira S. Lederman and Jeffrey M. Hafter who are sworn to me to be the Executive Vice President and Secretary, and the Senior Vice President, respectively, of Berkley Insurance Company.

MARIA C RUNDBAKEN
NOTARY PUBLIC
CONNECTICUT
MY COMMISSION EXPIRES
APRIL 30, 2024

_____
Notary Public, State of Connecticut

**CERTIFICATE**

I, the undersigned, Assistant Secretary of BERKLEY INSURANCE COMPANY, DO HEREBY CERTIFY that the foregoing is a true, correct and complete copy of the original Power of Attorney; that said Power of Attorney has not been revoked or rescinded and that the authority of the Attorney-in-Fact set forth therein, who executed the bond or undertaking to which this Power of Attorney is attached, is in full force and effect as of this date.

Given under my hand and seal of the Company, this 17th day of November, 2023.

BERKLEY INSURANCE COMPANY CORPORATE SEAL 1975 DELAWARE

_____
Vincent P. Forte

Please **verify the authenticity** of the instrument attached to this power by:

Toll-Free Telephone: (866) 768-3534; or

Electronic Mail: BSGInquiry@berkleysurety.com

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Any written notices, inquiries, claims or demands to the Surety on the bond attached to this power should be directed to:

Berkley Surety Group
412 Mount Kemble Ave.
Suite 310N
Morristown, NJ 07960
Attention: Surety Claims Department

**Or**

Email: BSGClaim@berkleysurety.com

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Please include with all communications the bond number and the name of the principal on the bond. Where a claim is being asserted, please set forth generally the basis of the claim. In the case of a payment or performance bond please also identify the project to which the bond pertains.

Berkley Surety Group is an operating unit of W. R. Berkley Corporation that underwrites surety business on behalf of Berkley Insurance Company and Berkley Regional Insurance Company

# APPENDIX H—PETROPHYSICAL REPORT

A petrophysical report consisting of data and interpretations from the EWS Hub characterization well, Juniper M-1 (49-021-29548), is provided in the following document.

## Data Gathering, Quality Control, and Petrophysical Analysis Methodology

The vendor, SLB, ensured all calibrations were properly conducted and within recommended tolerances. The logging operation included running of the tools listed in Table 58.

Table H.1—Logging Plan for Juniper M-1.

| Trip | Hole Section | Logging Suite | Target Data Acquisition |
|---|---|---|---|
| 1 | Surface 0 ft to 1,565 ft (Cased Hole) | Caliper | Identification of Rock Properties |
| | | Gamma Ray | |
| | | Resistivity (SP) | |
| | | Density | |
| | | Neutron | |
| | | Sonic/Acoustic | |
| 1 | Pilot 1,565 ft to TD (Open Hole) | Gamma Ray | Identification of Rock Properties |
| | | Resistivity | |
| | | Density | |
| | | Neutron | |
| | | Spectral GR | |
| 2 | | Magnetic Resonance | Pore Size Distribution |
| | | Dielectric | |
| | | Spectroscopy | Mineralogy |
| | | Gamma Ray | |
| 3 | | Sonic/Acoustic | Mechanical Properties and Synthetic Ties |
| | | Orientation | Aid in Cement Calcs |
| | | Multi-arm Caliper | |
| | | Gamma Ray | |
| | | Oil-based Image | Fracture/Fault/Structure |
| | | Ultrasonic Image | |
| 4 | | MDT Wireline Formation Tester (WFT) | Formation Fluid Samples, Pressure Measurements |
| 6 | | Sidewall Coring | Sidewall Cores |
| | | Gamma Ray | |

Note that spontaneous potential (SP) was not collected due to the presence of oil-based mud in the hole. The MDT was run yet was unsuccessful in obtaining a fluid sample.

Core was collected across the Chugwater, Goose Egg, Lyons and Satanka Formations (Figure 2). Collected log data was tied to core analysis to fully incorporate all available datasets from the Juniper M-1 well. These data were included to perform petrophysical ties to core-based porosity, permeability, and mineralogy. A core gamma ray curve was compared to total gamma ray in order to ensure the core and wireline logs were depth matched (Figure 2). As a result, a depth shift of

+10.5 ft was observed between the acquired core and wireline data and applied to the original core depth values (Figure 2). Figures 2 and 3 display the petrophysical and multi-mineral interpretations from the Juniper M-1. Full resolution versions of Figures 2 and 3 are also attached in Appendix A. Individual core point values are plotted with corresponding log curves to demonstrate an agreement between the porosity, permeability, and multi-mineral datasets. These figures also identify the depths of water samples collected from the Lyons Formation in yellow.

A track-by-track explanation of the Petrophysical data and interpretation presented in Figures 2, 4, 6, 8, 10 is as follows:

- **Correlation track**: caliper (CALI), bit size (BIT), total gamma ray (GRT), and gamma ray emissions from potassium and thorium only (GRKTH). The separation between GRKTH and GRT indicates the presence of uranium, which is commonly associated with shale rock.
- **Depth track**: contains the measured depth (MD) in feet and formation tops.
- **Resistivity track**: resistivity logs (shallow, medium, deep depths of investigation). Where the three logs overlay, it indicates no fluid invasion of mud filtrate and consequently low permeability. Separation of these curves could indicate elevated permeability.
- **Porosity track**: logs pertaining to formation porosity including neutron porosity (PHIN_SS) and bulk density (RHOB_SS) assuming a quartz sandstone grain density of 2.65 g/cm$^3$. In clean shale-free sandstone intervals with liquid filled porosity, the two porosity curves will overlay. The photoelectric factor (PEF) curve is also displayed in this track and aids in determining lithology.
- **Computed Porosity track**: contains computed total (PHIT) and effective (PHIE) porosity from the Quanti.Elan™ multi-mineral (multi-min) workflow provided by SLB.
- **Grain density track:** contains the computed grain density (RHOG) and core grain density (black circles).
- **Saturation track**: contains the effective and total water saturation curves. The red numbers printed on the track are formation temperature (degrees Fahrenheit) as measured by DTS Fiber.
- **Minerals track**: the mineral volumes estimated from the Quanti.Elan™ multi-mineral (multimin) workflow, the details of which are discussed with Figure 2 explanation below.
- **Permeability track**: contains the calculated permeability based on core porosity-permeability relationships. The regression in Figure 1 was used to develop the porosity-permeability transform.

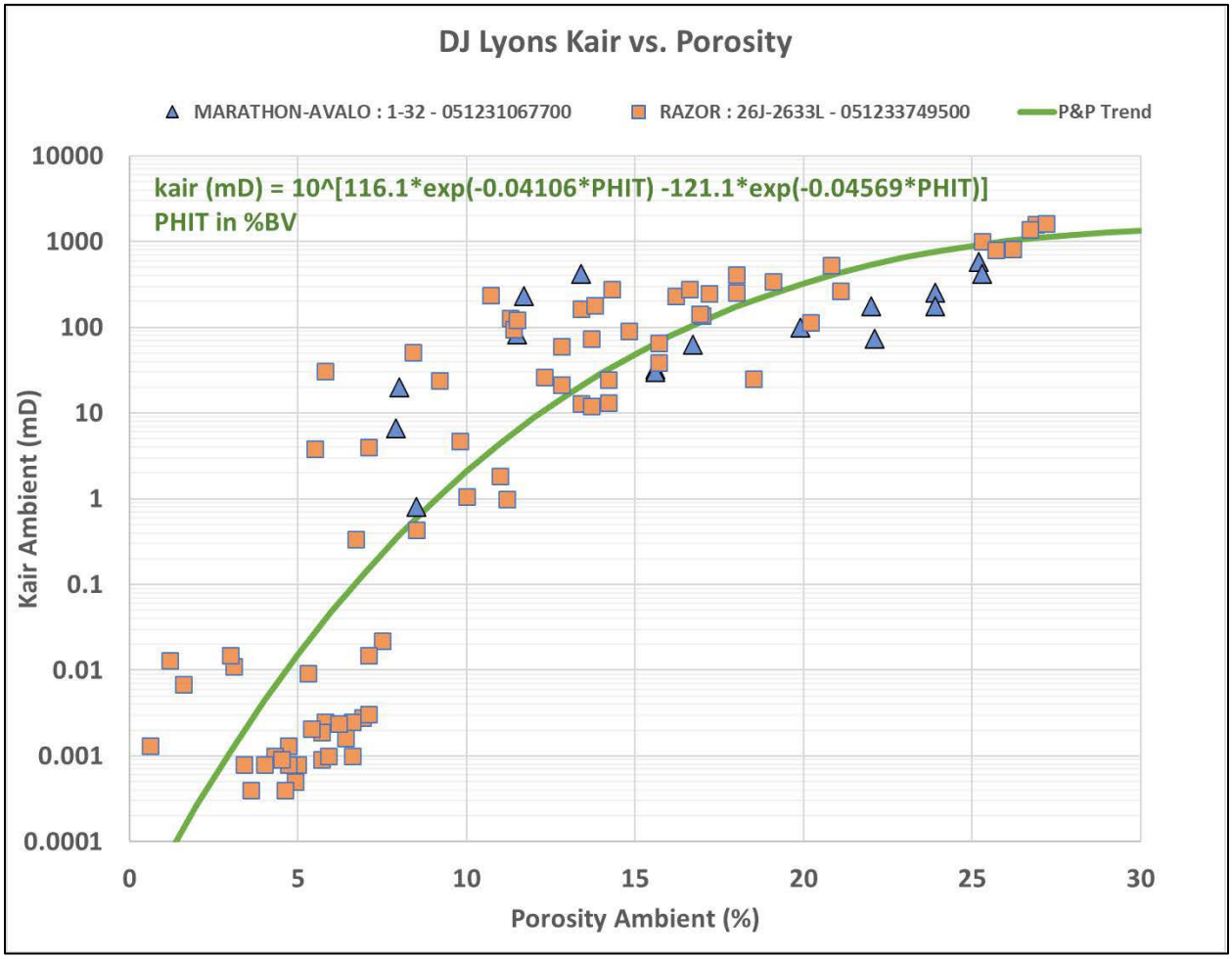



Figure H.1—Permeability-porosity transform for this project.

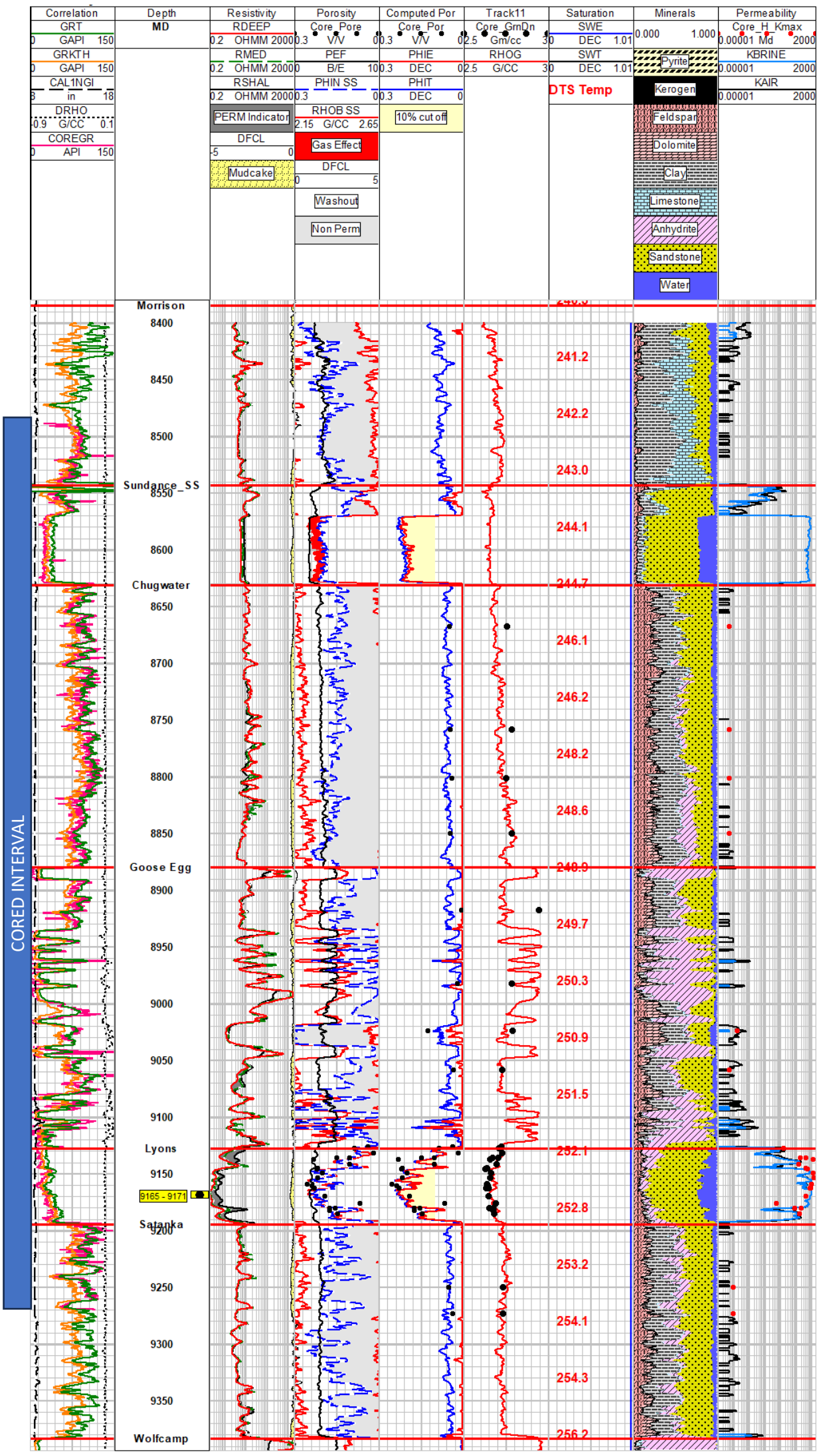



Figure H.2—Petrophysical interpretation from the Juniper M-1 (API No. 49-021-29548).

Figure 3 presents an overview of the injection zone (Lyons), upper (Goose Egg) and lower confining zones (Satanka), with individual tracks representing the results of the multi-mineral analysis (multimin). Multimin workflows use multiple inputs of log data and core data to perform a matrix inversion process. Outputs include lithologic volumetrics such as quartz volume as well as rock properties such as porosity. Multi-mineral derived volumes are then compared to mineralogical core data (solid black circles in Figures 3, 5, 7, 9, 11). A track-by-track explanation of the multi-mineral analysis results and interpretation presented in Figures 3, 5, 7, 9, 11 is as follows. Key observations are discussed for each of Figures 5, 7, 9, and 11.

- **Correlation track:** contains caliper (CALI), bit size (BIT), total gamma ray (GRT), and gamma ray emissions from potassium and thorium only (GRKTH). The separation between GRKTH and GRT indicates the presence of uranium.
- **Depth track**: contains the measured depth (MD) in feet and formation tops.
- **Clay track**: Volume of Clay from multi-mineral analysis, volume increases to right
- **Sandstone track**: Volume of Quartz, increasing to right
- **Pyrite track:** Volume of Pyrite, increasing to left
- **Feldspar track:** Volume of Feldspar, increasing to left
- **Limestone track:** Volume of Limestone, increasing to left

- **Anhydrite track:** Volume of Anhydrite, increasing to left
- **Dolomite track:** Volume of Dolomite, increasing to left
- **Grain Density track:** Computed grain density (RHOG) in gm/cm3, increasing to right
- **Total Porosity track:** Total porosity based on combination of variable grain density and recorded bulk density log. Porosity increases to left.

Observations and take-away points based on log and core data will be discussed in their respective sections that follow.

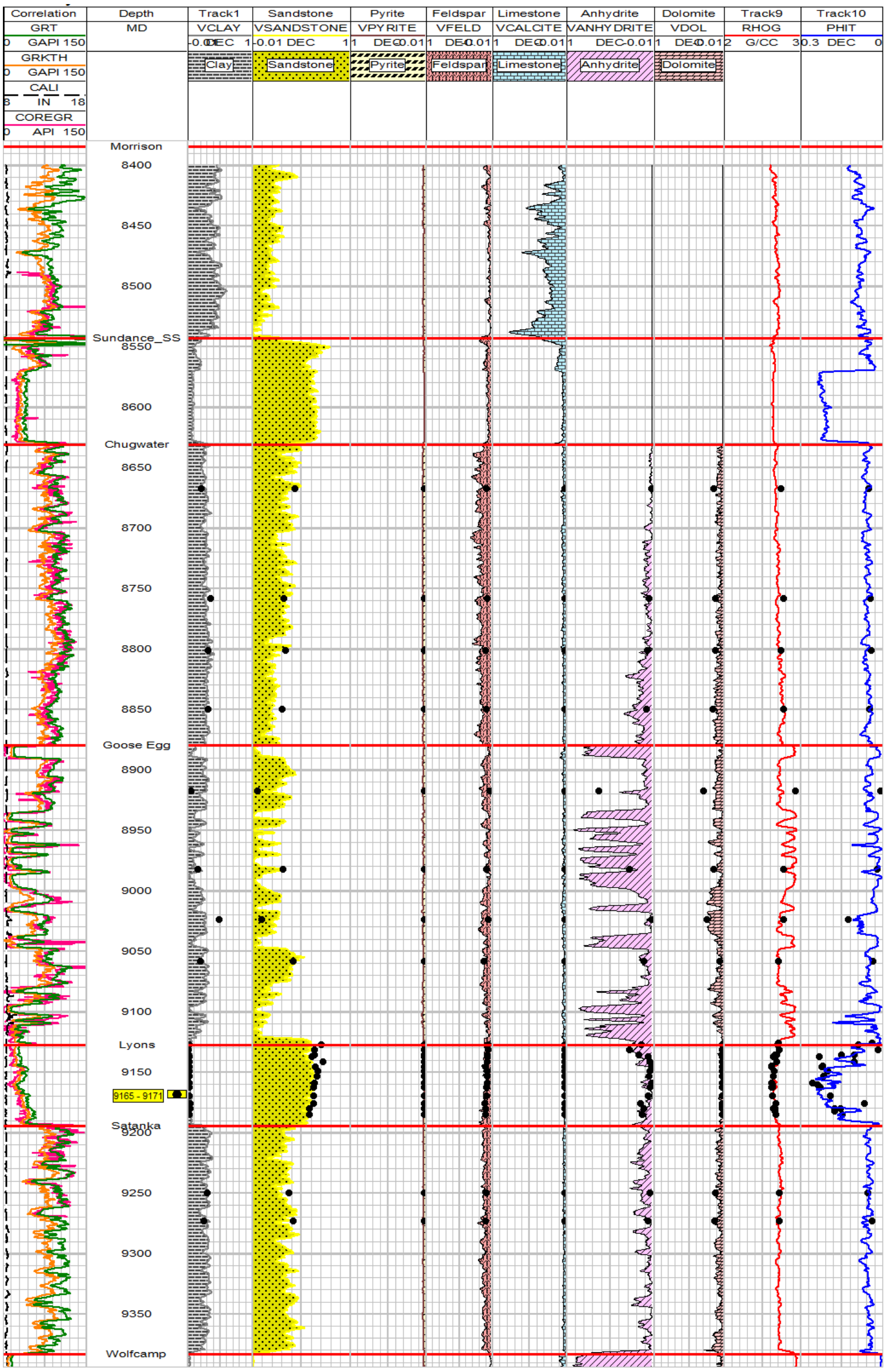


Figure H.3—Multi-mineral interpretation from the Juniper M-1 (API No. 49-021-29548).

**Upper Confining Interval: Chugwater Formation**

The Chugwater Formation consists of interbedded red silt and shale with increasing evaporate content towards the base of the section. Petrophysical and multi-mineral interpretations of the Chugwater Formation are included in Figures 3 and 4 for reference.

*Petrophysical plot observations and interpretations (Figure 4):*

- **Correlation track**: Elevated GRT and GRKTH suggest significant clay content from top of Chugwater to base. Caliper reads slightly less than the drill bit size indicating the presence of mudcake.
- **Depth track**: Chugwater Formation extends from 8628' MD to 8844' MD.
- **Resistivity track**: Shallow and Deep resistivity generally overlay indicating low permeability
- **Porosity track**: Bulk density (RHOB_SS) and neutron porosity (PHIN_SS) separate, indicating the Chugwater is a shaly interval with low porosity which is supported by core porosity data.
- **Computer Porosity track**: Total (PHIT) and effective porosity (PHIE) are plotted along with core porosity data. While the total porosity averages roughly 4%, effective porosity is near zero.
- **Saturation track**: Water Saturation is uniformly 100% in the matrix. No hydrocarbon intervals were identified. Note that the effective and bound saturations both equal 1.
- **Minerals track**: Multi-mineral analysis indicates Chugwater contains roughly 30% clay minerals, 30% feldspar and 30% quartz. From 8880' MD to base 10-20% Anhydrite is present variably displacing clay or quartz in the matrix.
- **Permeability track**: Permeability is consistently very low (< 0.001 mD) over entire interval.

*Multi-mineral observations and interpretations (Figure 5):*

- **Correlation track**: Elevated GRT and GRKTH suggest significant clay content from top of Chugwater to base. Caliper reads slightly less than the drill bit size indicating the presence of mudcake.
- **Depth track**: Chugwater Formation extends from 8628' MD to 8844' MD.
- **Clay content track**: Clay content from multi-mineral analysis agrees well with core XRD data indicating clay varies from 25-35% and averages ~30%
- **Sandstone track**: Quartz content varies from 15 to nearly 50% and the core XRD results suggested higher quartz.
- **Pyrite track**: Pyrite was not noted in the Chugwater
- **Feldspar track**: Feldspar varied from 10-20% and the core XRD results suggested lower feldspar.
- **Limestone track**: Calcite was not identified in the core XRD and remained very low in the multi-mineral analysis.
- **Anhydrite track**: Anhydrite volume gradually increases from top towards the base of the Chugwater and ranges from 0% to as high as 35% of the matrix.

- **Dolomite track**: The presence of dolomite is uniformly low and makes up less than 5% of the matrix on average.
- **Grain density track**: Grain Density remains consistent throughout the Chugwater but does increase from 2.65 gm/cm3 towards the base as the anhydrite fraction increases.
- **Total porosity track**: Total Porosity remains low throughout the interval averaging about 5%.

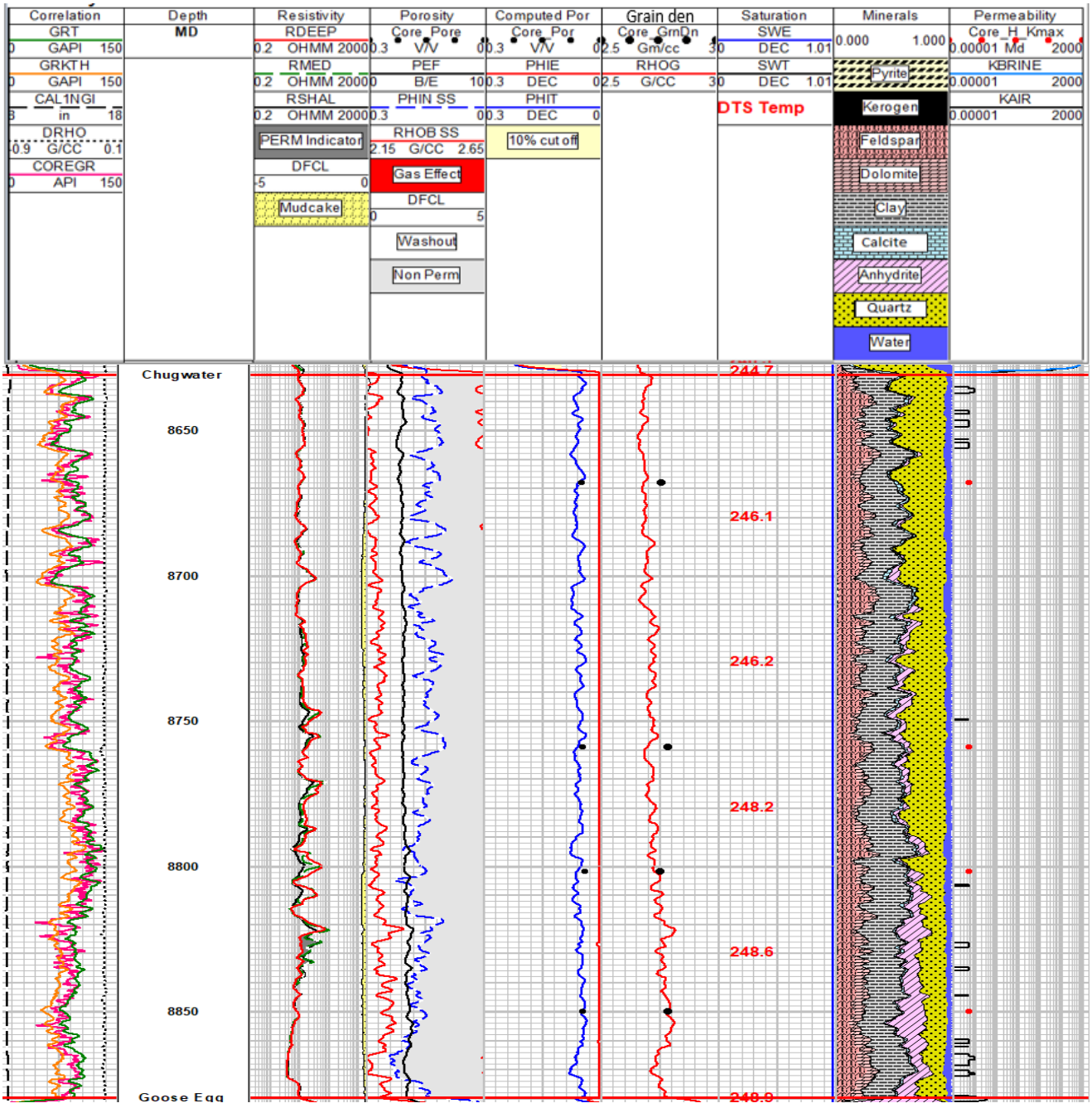



Figure H.4—Petrophysical interpretation of the Chugwater Formation; Juniper M-1 (API No. 49-021-29548).

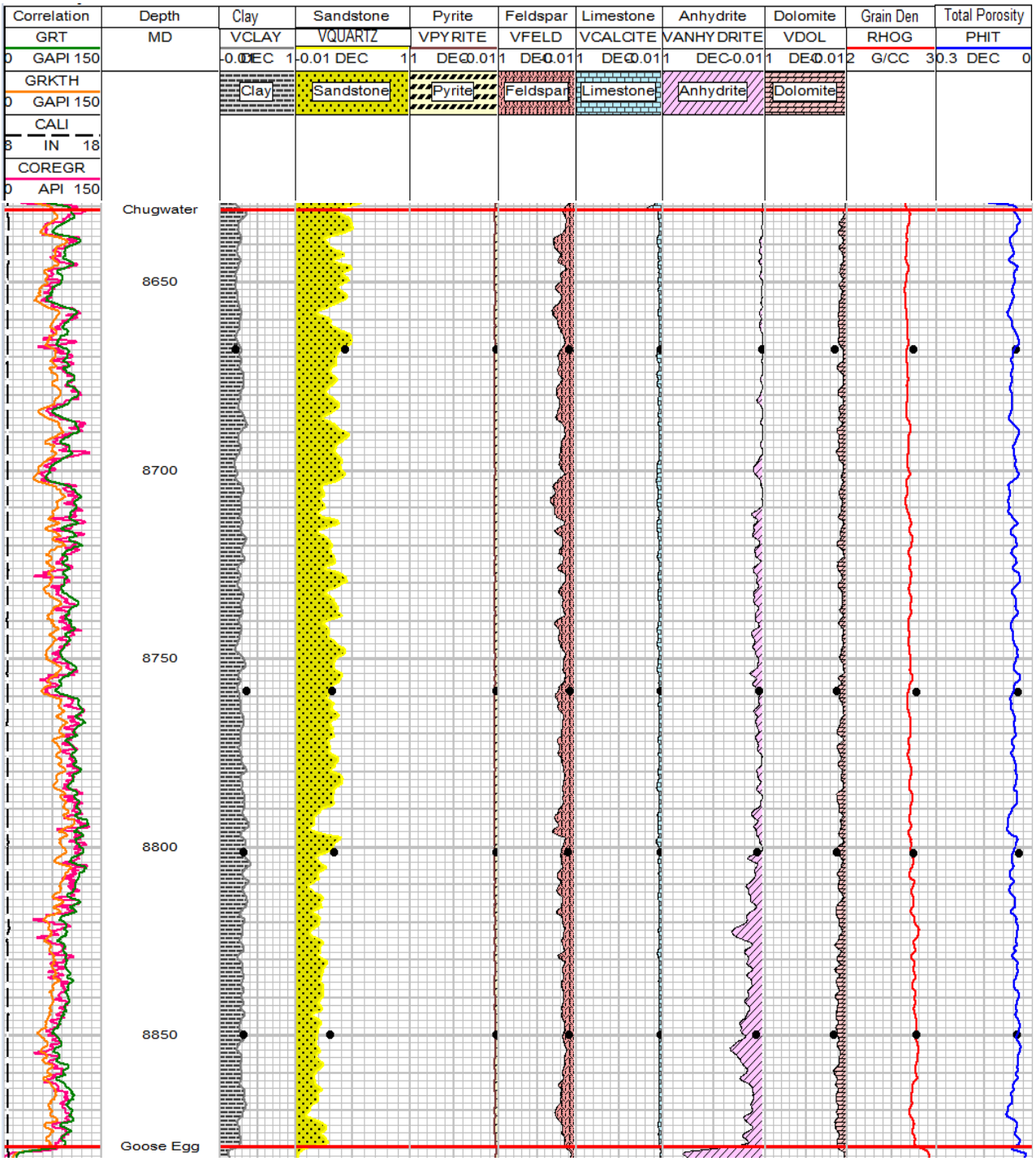



Figure H.5—Multi-mineral interpretation of the Chugwater Formation; Juniper M-1 (API No. 49-021-29548).

These figures demonstrate the Chugwater Formation contains elevated total gamma ray (GRT) values throughout the section, indicating the presence of radioactive and clay-rich minerals, known for their low permeability and sealing capability. This interpretation agrees with x-ray diffraction (XRD) data acquired from core analysis of the Chugwater Formation in the Juniper M-1 well. Figure 5 displays volume percent curves of commonly identified minerals relative to individual core points obtained in the core analysis. The multi-mineral curves track closely with plotted core values, demonstrating agreement between datasets and improved confidence in the multi-mineral model. Total porosity also tracks well with correlated core points and suggests porosity within the Chugwater Formation is low. The overlap, or lack of separation between shallow resistivity and deep resistivity curves indicates low permeability. All datasets support a thick, tight, secondary upper confining interval. The total porosity averages 5% over the interval and the calculated permeability for the Chugwater is less than 0.001 mD.

**Primary Upper Confining Interval: Goose Egg Formation**

The Goose Egg Formation consists of an interbedded sequence of evaporites and shale, as depicted in the petrophysical and multi-mineral interpretations supplied in Figures 6 and 7.

*Petrophysical observations and interpretations (Figure 6)*

- **Correlation track**: GRT and GRKTH suggest shaly intervals contain significant clay content. Interspersed are intervals with low Gamma Ray emissivity which are interpreted to be evaporite intervals. Caliper reads slightly less than the drill bit size indicating the presence of mudcake.
- **Depth track**: Goose Egg Formation extends from 8844’ MD to 9126’ MD.
- **Resistivity track**: Shallow and Deep resistivity show only a few isolated intervals with any separation which may indicate permeability. These separation features could be due to thin-bed effects.
- **Porosity track**: PEF curve indicates complex lithologies ranging from shale to evaporites with some shale intervals having a significant dolomitic component.
- **Computed porosity track**: Total (PHIT) and effective porosity (PHIE) are plotted along with core porosity data. While the total porosity peaks at 12% but averages roughly 5%, effective porosity is near zero except for a few isolated shale or silt intervals.
- **Saturation track**: Water Saturation is uniformly 100% in the matrix. No hydrocarbon intervals were identified.
- **Minerals track**: Multi-mineral results indicate variable lithology and an interbedded sequence of evaporites and shales.
- **Permeability track**: Permeability is consistently very low (< 0.001 mD) with only minor isolated intervals above that threshold.

*Multi-mineral observations and interpretations (Figure 7)*

- **Correlation track**: GRT and GRKTH suggest shaly intervals contain significant clay content. Interspersed are intervals with low Gamma Ray emissivity which are interpreted to be

evaporite intervals. Caliper reads slightly less than the drill bit size indicating the presence of mudcake.

- **Depth track**: Goose Egg Formation extends from 8844' MD to 9126' MD.
- **Clay track**: Clay content from multi-mineral analysis indicates clay varies from near zero to 35% in some intervals. Core XRD clay volume shows more irregularity but could be explained due to thinly bedded lithologies.
- **Sandstone track**: Quartz content varies from near zero in the evaporite intervals to nearly 50% in some of the shaly intervals.
- **Pyrite track**: Pyrite was not noted in the interval and is supported by core XRD.
- **Feldspar track**: Feldspar varied from 5-20% and the core XRD results suggested lower feldspar.
- **Limestone track**: Calcite was not identified in the core XRD and remained very low in the multi-mineral analysis.
- **Anhydrite track**: Anhydrite volume is highly variable, ranging from ~5% in shaly intervals to 90 % in some evaporite intervals.
- **Dolomite track**: The presence of dolomite is variable and makes up less than 5% of the matrix on to a maximum of 25%.
- **Grain density track**: Grain Density is highly variable due to the presence of the evaporite intervals containing anhydrite with the shaly intervals averaging about 2.7 gm/cm3 and the evaporites approaching 3.0 gm/cm3.
- **Total porosity track**: Total Porosity is variable depending on lithology with the shaly intervals ranging from 5-10% whereas the evaporite intervals average 1-3%.

The total gamma ray (GRT) values vary in portions of the Goose Egg interval. Sections expressing clean or low GRT values indicate a relative increase in anhydrite. Sections expressing hot, or high GRT values, indicate the presence of clay. Figure 6 displays volume percent curves of commonly identified minerals relative to individual core points obtained from the Juniper M-1 core analysis. The multi-mineral curves track closely with plotted core values, demonstrating agreement between datasets and improved confidence in models. The total porosity curve also tracks well with correlated core points and suggests porosity within the Goose Egg interval is low. The overlap (*lack of separation*) between shallow resistivity and deep resistivity curves indicates low permeability. All datasets are in support of a thick, variable, but tight upper confining interval.

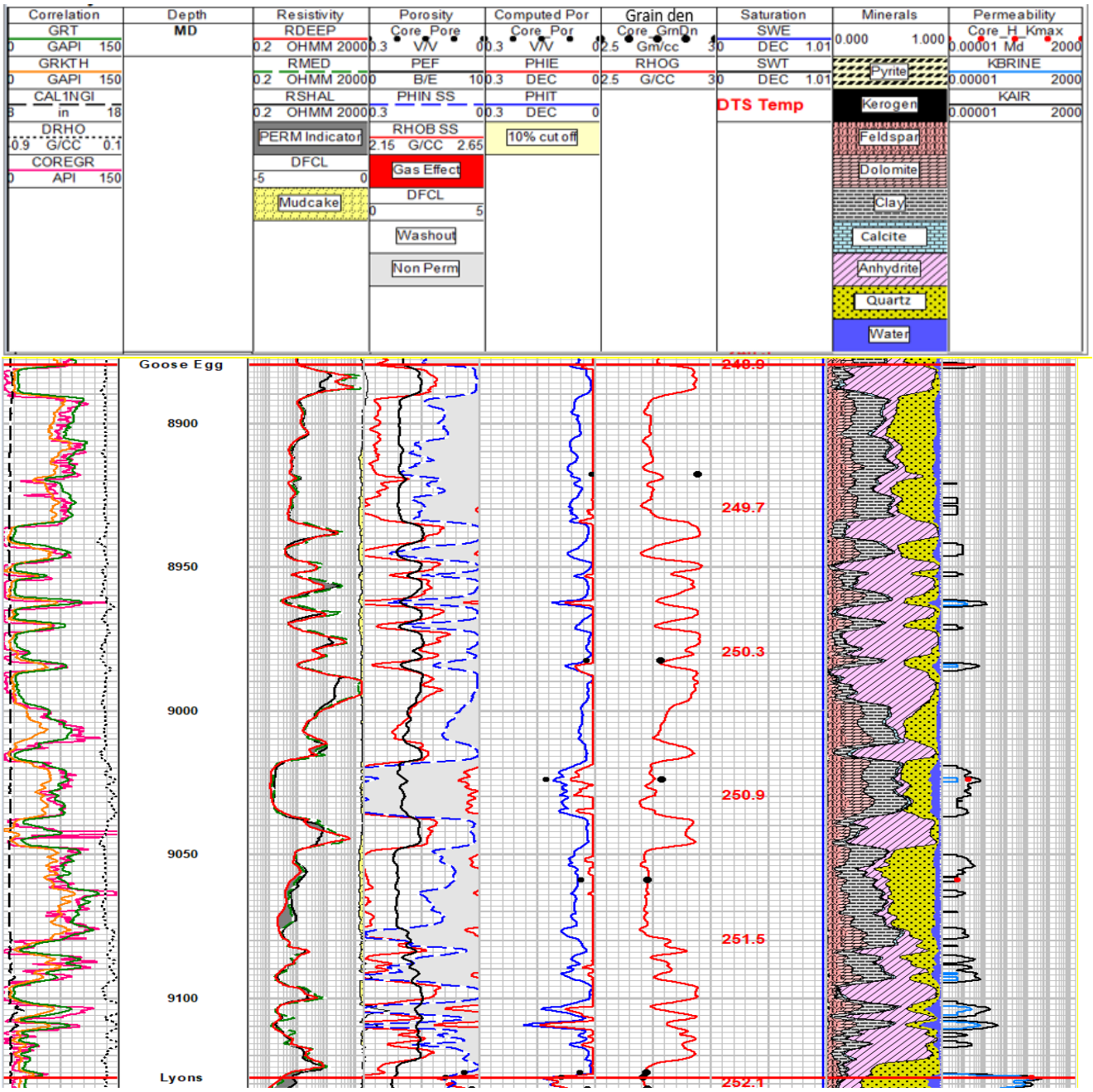



Figure H.6—Petrophysical interpretation of the Goose Egg Formation; Juniper M-1 (API No. 49-021-29548).

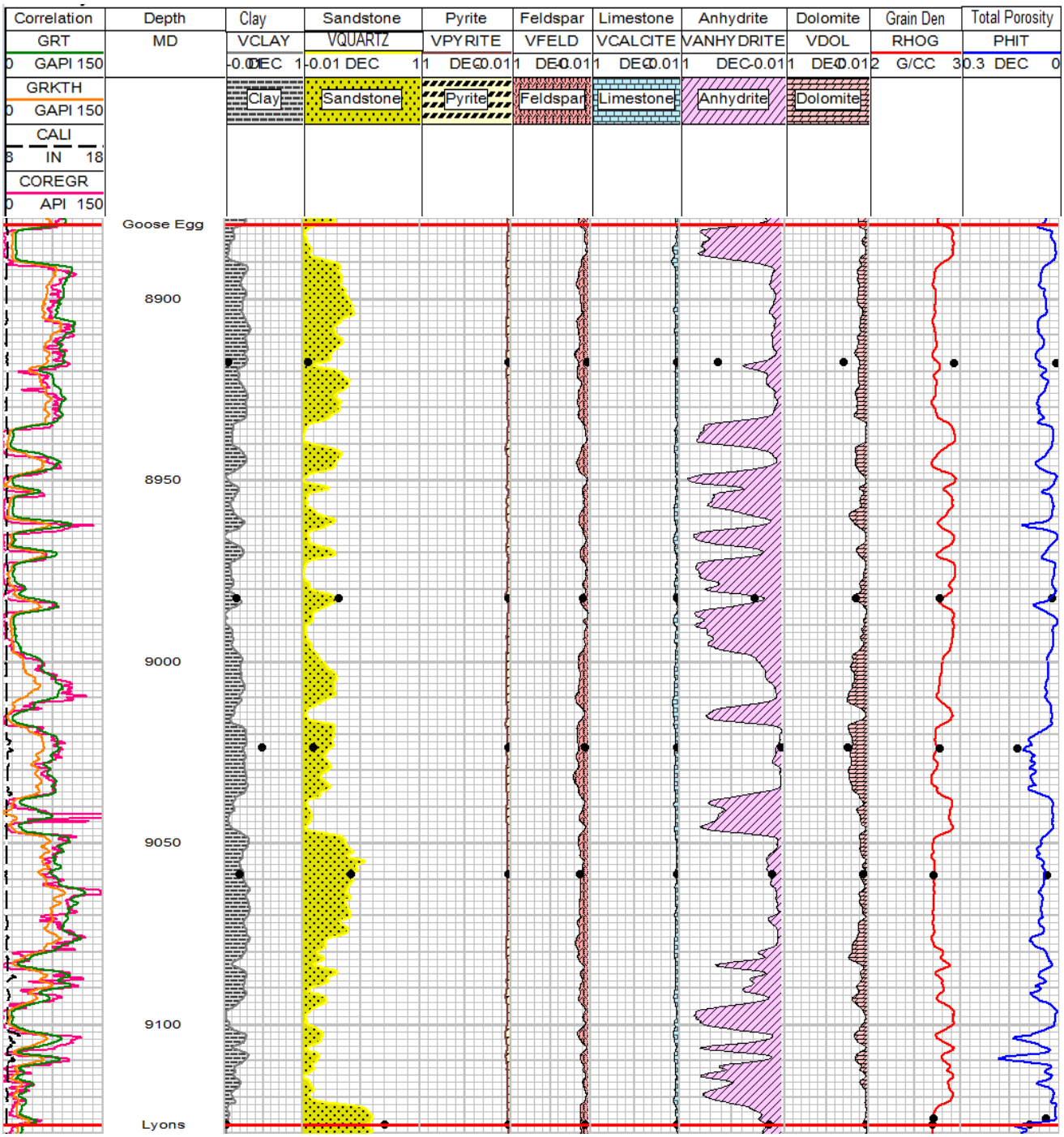



Figure H.7 - Multi-mineral interpretation of the Goose Egg Formation; Juniper M-1 (API No. 49-021-29548).

**Injection Interval: Lyons Formation**

Open-hole logs ran across the Lyons Formation intersected by the Juniper M-1 well indicate the presence of a clean, porous, and permeable sandstone section (Figures 8 and 9).

Four water samples were collected from the Lyons Formation using the Single-Phase Reservoir Sampler Tool (SRS). The SRS tool was selected because it maintains samples in a single-phase condition as the tool is retrieved from the hole, resulting in pressurized in-situ sample conditions. Technical specifications for the SRS tool are provided in Appendix A. The well was perforated in the Lyons Formation between the depths of 9,165 and 9,171 feet, swabbed, and water samples were collected from the depths of 9,066.67, 9,081.92, 9,096.26, and 9,066.67 feet. Please note that the reported sample collection depths are shallower than the top of Lyons; however, only the Lyons Formation was perforated at the time of collection so samples are representative of the Lyons Formation. Values in Table 13 of SC-16 represent the average of all four Lyons samples analyzed, no samples were excluded. The Lyons fluid samples are still being analyzed to understand the effects of mud on the TDS values.

*Petrophysical observations and interpretations* (Figure 8)

- **Correlation track**: GRT and GRKTH suggest low clay or radioactive mineral volume. Log readings gradually increase with depth. Caliper reads slightly less than the drill bit size indicating the presence of mudcake.
- **Depth track**: Lyons Formation extends from 9126' MD to 9192' MD.
- **Resistivity track**: Shallow and deep resistivity show significant separation which is an indicator of permeability.
- **Porosity track**: PEF curve indicates interval is a sandstone or shale with minimal limestone, or dolomite.
- **Computed Porosity track**: Total (PHIT) and effective porosity (PHIE) are plotted along with core porosity data. Over most of the interval the total and effective porosities exceed 15%. The computed log porosities match well with the measured core porosity.
- **Saturation track**: Water Saturation is uniformly 100% in the matrix. No hydrocarbon intervals were identified.
- **Minerals track**: Multi-mineral results indicate the Lyons Sandstone is predominantly a quartz sand with a minor evaporite component.
- **Permeability track**: Permeability averages 131 mD over the entire Lyons interval with 280 mD over the interval with Phit > 10% or 307 mD over the interval with Phie > 10%

*Multi-mineral observations and interpretations* (Figure 9)

- **Correlation track**: GRT and GRKTH suggest low clay or radioactive mineral volume. Log readings gradually increase with depth. Caliper reads slightly less than the drill bit size indicating the presence of mudcake.
- **Depth track**: Lyons Formation extends from 9126' MD to 9192' MD.
- **Clay track**: Clay content from multi-mineral analysis indicates clay volume is very low over the interval. Core XRD clay volume supports the interpretation.
- **Sandstone track**: Quartz content varies from 50% to nearly 70% with the core XRD results supporting a slightly higher quartz volume.
- **Pyrite track**: Pyrite was not noted in the interval and is supported by core XRD.
- **Feldspar track:** Feldspar was low, typically less than 10% and the core XRD supported the value.

- **Limestone track**: Calcite was not identified in the core XRD and remained very low in the multi-mineral analysis.
- **Anhydrite track**: Anhydrite volume is somewhat variable and was near zero in the middle of the Lyons and increased to 10% towards the top and base of the formation.
- **Dolomite track**: The presence of dolomite was low, less than 5% and well supported by core XRD data.
- **Grain density track**: Grain Density is consistent and supported by core data at 2.65 gm/cm3.
- **Total Porosity track**: Total Porosity in the highest reservoir quality intervals approaches 20% with roughly 66% of the interval above 10% porosity.

Total gamma ray (GRT) values tend to be clean (*values plot closer to zero on scalebar*) with a tight overlap of spectral gamma ray curves, indicating the presence of a clean sandstone with a general lack of radioactive or clay-rich minerals. Total porosity (PHIT) and mineral fractions were estimated using the Quanti.Elan™ multi-mineral workflow by SLB. The Quanti.Elan™ results further corroborate the Lyons Formation primarily consists of quartz sandstone with a grain density of approximately 2.65 g/cm$^3$. The total porosity (PHIT) and permeability (KBRINE) curves track closely with plotted core values, depicted as black points on the porosity track and red points on the permeability track. The model is well calibrated as the measured core and the measured and calculated logs corroborate each other. Permeability of the Lyons Formation is also suggested by the separation observed between shallow resistivity (RSHAL) and deep resistivity (RDEEP) curves, a common permeability indicator. A SP log was not recorded in this well due to the well being drilled with oil-based mud (OBM). Mudlogging and Quanti.Elan™ results indicate the Lyons pore space is filled with water only and no hydrocarbons.

Reservoir quality rock within the Lyons was determined by a PHIT cutoff of $\geq$ 10% and is indicated in Figure 8 with yellow shading. The cutoff identified 54.3 net feet of reservoir out of the 66.7 gross feet of Lyons Formation with a net to gross ratio of 81.4% and an average reservoir porosity of 17.6%.

A few tight streaks are also present within the Lyons Formation. However, wireline measurements are taken near wellbore with relatively shallow horizontal resolution, so the lateral continuity of tight lithologies is not represented. The thin, low perm intervals are not included in the Lyons net reservoir or injection model due to porosities lower than 10%.

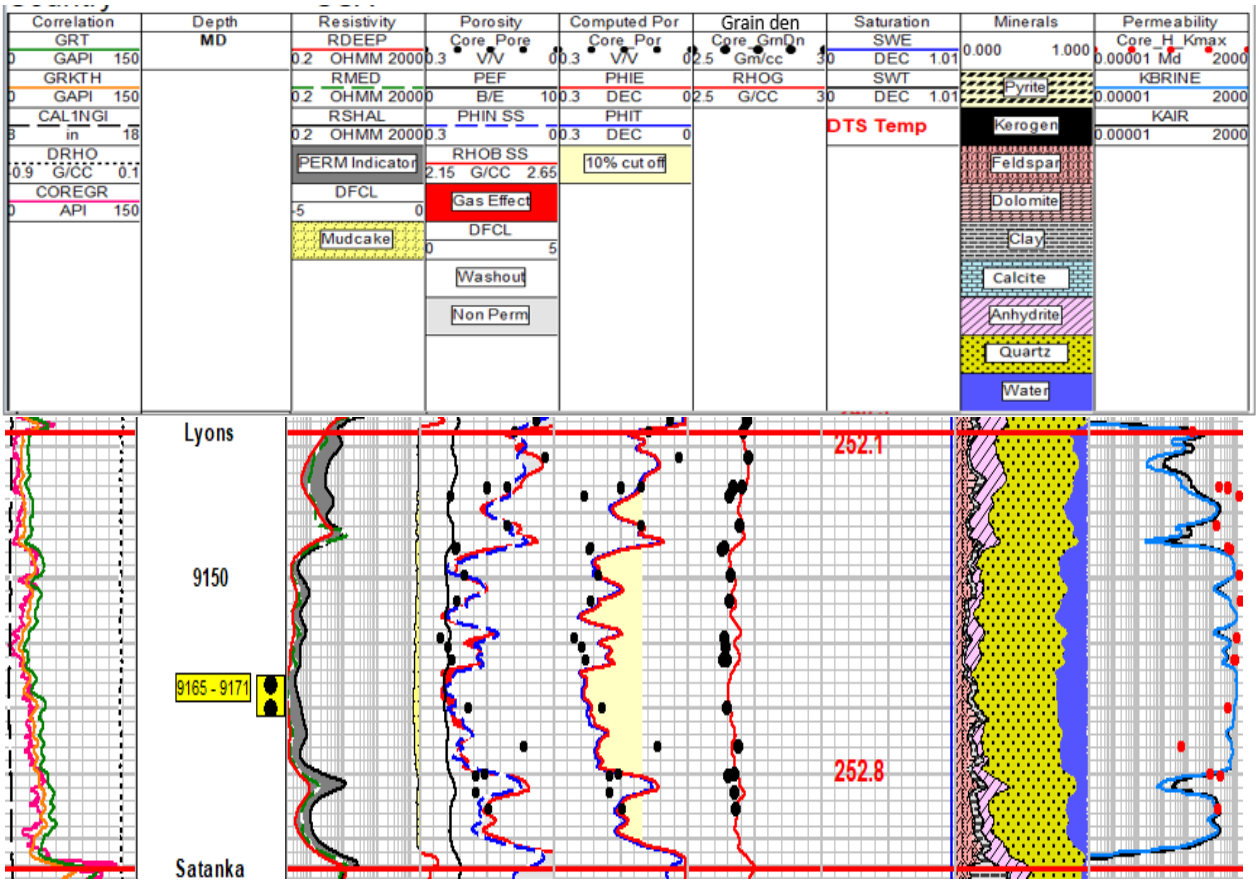



Figure H.8 - Petrophysical interpretation of the Lyons Formation; Juniper M-1 (API No. 49-021-29548).

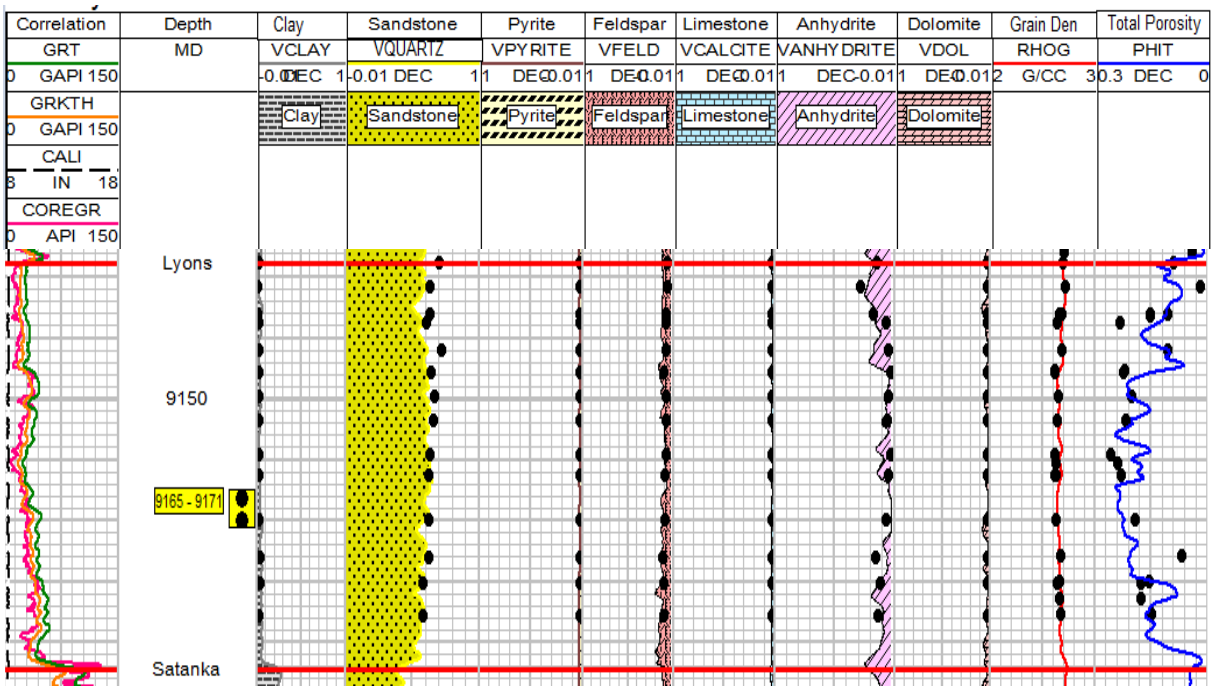



Figure H.9 - Multi-mineral interpretation of the Lyons Formation; Juniper M-1 (API No. 49-021-29548).

**Lower Confining Interval: Satanka Formation**

The Satanka formation consists of red interbedded silt and shale with some evaporate content, as supported by the petrophysical and multi-mineral interpretations supplied in Figures 9 and 10.

*Petrophysical observations and interpretations* (Figure 10)

- **Correlation track**: GRT and GRKTH suggest significant clay or radioactive mineral volume Caliper reads slightly less than the drill bit size indicating the presence of mudcake.
- **Depth track**: The Satanka Formation extends from 9192’ MD to 9352’ MD.
- **Resistivity track**: Shallow and deep resistivity show no separation which is an indicator of permeability, suggesting the interval has uniformly low permeability.
- **Porosity track**: PEF curve indicates interval is a sandstone or shale with minimal limestone, or dolomite.
- **Computed porosity track**: Total (PHIT) and effective porosity (PHIE) are plotted along with core porosity data. The total porosity ranges from 3-8 % whereas the effective porosity is zero with a few isolated exceptions. The computed log porosities match well with the measured core porosity.
- **Saturation track**: Water Saturation is uniformly 100% in the matrix. No hydrocarbon intervals were identified.
- **Mineral track**: Multi-mineral results indicate the Satanka is predominantly a shale with a minor evaporite component.
- **Permeability track**: Permeability is less than 0.001 mD over the entire interval.

*Multi-mineral observations and interpretations* (Figure 11)

- **Correlation track**: GRT and GRKTH suggest significant clay or radioactive mineral volume Caliper reads slightly less than the drill bit size indicating the presence of mudcake.
- **Depth track**: The Satanka Formation extends from 9192' MD to 9352' MD.
- **Clay track**: Clay content from multi-mineral analysis indicates clay volume averages 30-35% consistently over the interval. Core XRD clay volume support the interpretation.
- **Sandstone track**: Quartz content varies from 25% to 40% with the core XRD results supporting a slightly higher quartz volumes.
- **Pyrite track**: Pyrite was not noted in the interval and is supported by core XRD.
- **Feldspar track**: Feldspar was low, typically less than 20% and the core XRD results were slightly lower.
- **Limestone track**: Calcite was not identified in the core XRD and remained very low in the multi-mineral analysis.
- **Anhydrite track**: Anhydrite volume is somewhat variable and varied from near zero to 25% of the matrix volume, averaging less than 10%.
- **Dolomite track**: The presence of dolomite was low, less than 10% and well supported by core XRD data.
- **Grain density track**: Grain Density is consistent and supported by core data at 2.7 gm/cm3.
- **Total porosity track**: Total Porosity is low and generally remained between 3 and 6% over the interval.

The Satanka formation displays elevated GRT values that indicate the presence of radioactive clay minerals. Variation present within the GRT curve indicates changes in mineralogy that likely represent cyclic deposition between silt, shale, and evaporite sequences. Figure 10 displays volume percent curves of commonly identified minerals relative to individual core points obtained from Juniper M-1 core analysis. The multi-mineral curves track closely with plotted core values, demonstrating agreement between datasets and improved confidence in the multi-mineral model. Total porosity also tracks well with correlated core points and suggests porosity within the Satanka Formation is very low. The overlap between the shallow resistivity and deep resistivity curves indicates low permeability. All datasets support the concept of a thick and tight lower confining interval.

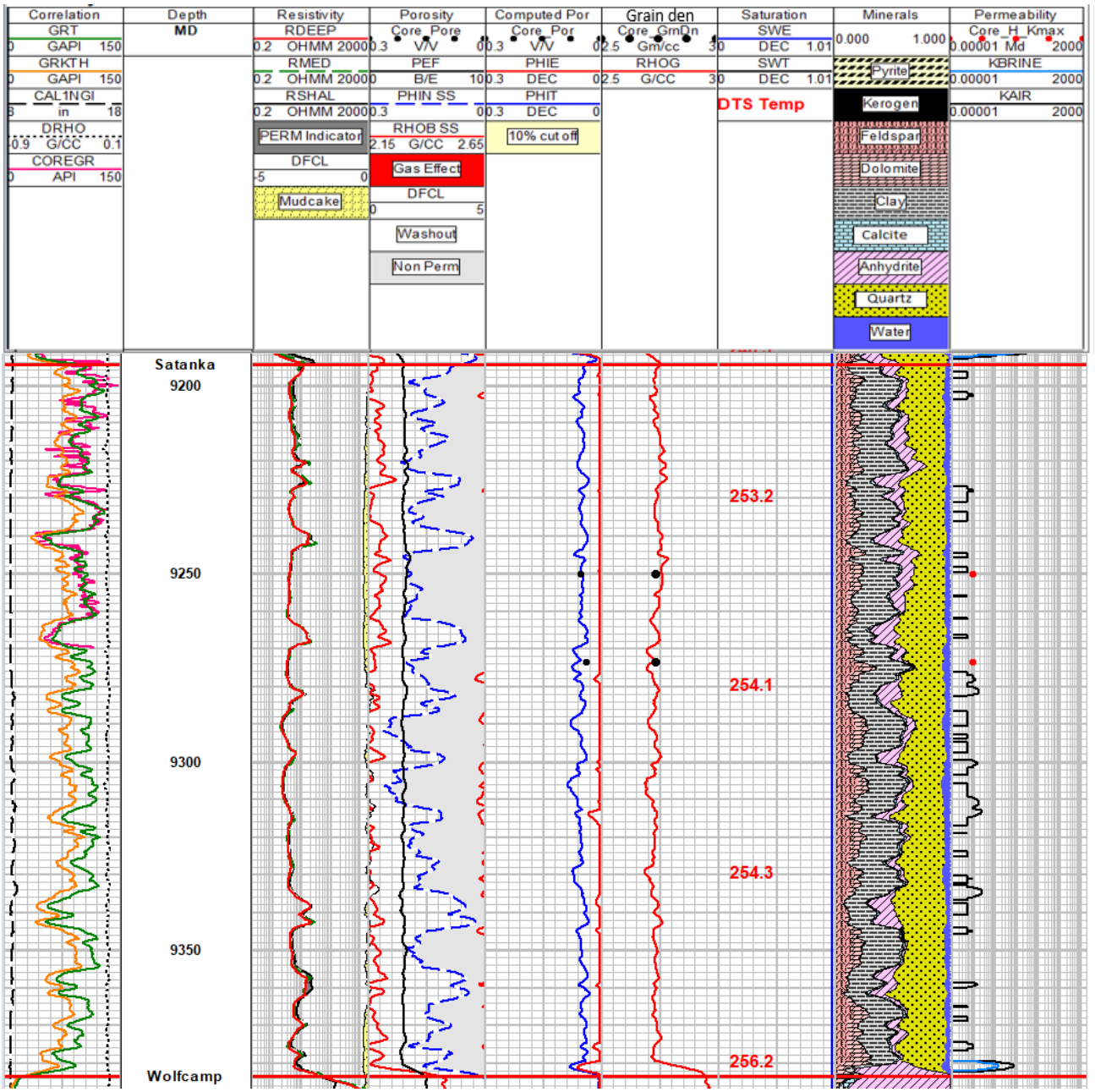



Figure H.10 - Petrophysical Interpretation of the Satanka Formation; Juniper M-1 (API No. 49-021-29548).

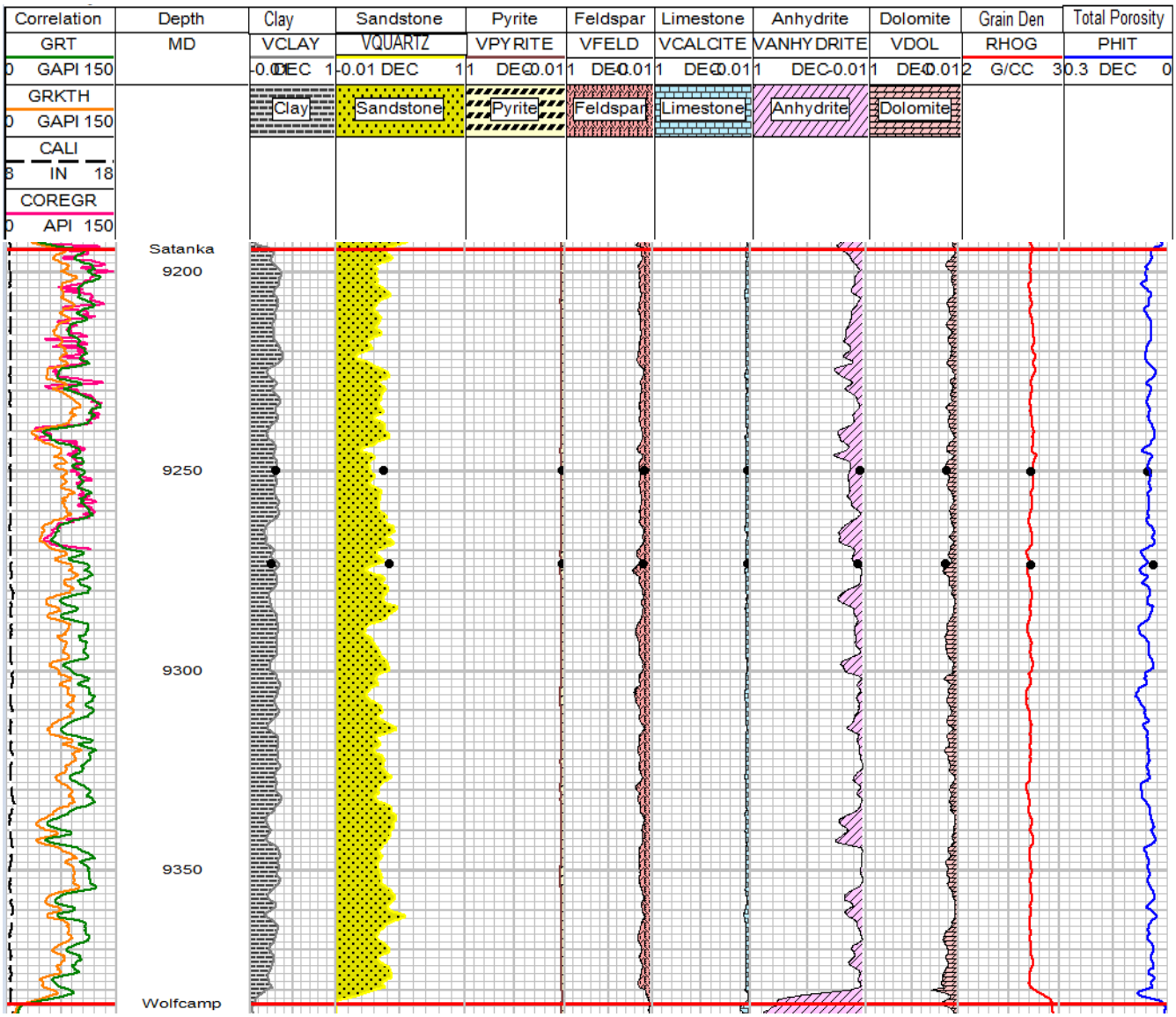



Figure H.11 - Multi-mineral interpretation of the Satanka Formation; Juniper M-1 (API No. 49-021-29548).

**SLB Image Log Analysis and Interpretation**

High Plains ran oil-based and ultrasonic borehole image and dipole sonic logs across the injection and confining intervals in Juniper M-1 to understand if these intervals contain transmissive faults or fractures (Figure 12). Data collected and interpreted from Juniper M-1 indicates that the Goose Egg and Chugwater confining layers are free of transmissive faults and fractures.

No open fractures or faults are observed in the first 35 ft of the Goose Egg formation, which directly overlies the Lyons Formation. The remainder of the confining zones contains occasional partly open and open fractures, none of which are interpreted as being transmissive. Fracture openness is interpreted to be caused by the drilling of Juniper M-1 due to the very limited

anisotropic response from the dipole sonic Stoneley waves. Stoneley waves are significantly impacted by the presence of open fractures. Additionally, the dipole sonic tool provides a wider horizontal depth of investigation than the oil based and ultrasonic image logs, which allows the dipole tool to collect data from deeper in the formation and infer whether open fracturing continues away from the wellbore.

Summary interpretation of the two sets of image logs determined:

- No transmissive fractures or faults were identified in the confining zones.
- Increased fracturing intensity occurs within the Chugwater Formation and the Minnekahta member of the Goose Egg Formation.
    - Fractures are not transmissive.
- Fractures are interpreted to have opened during the drilling process.
- Shale intervals within the section display bedding deformation, borehole breakout, open fracturing (due to drilling), and potential mechanically weak beds.

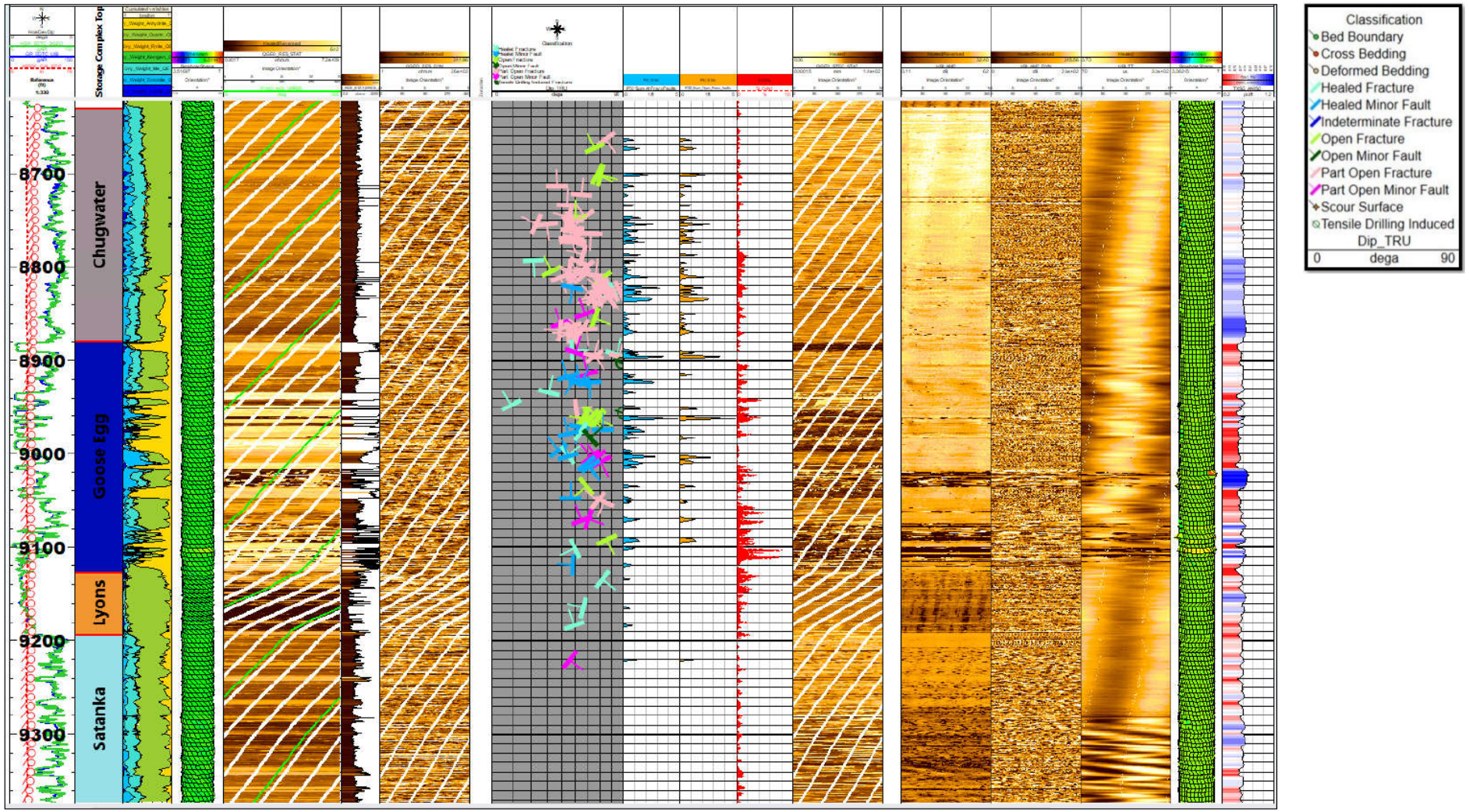



Figure H.12 – SLB Borehole Image Interpretation from the Juniper M-1 Storage Complex (API No. 49-021-29548).

Exhibit A: Routine vertical core analyses from Juniper M-1.

Exhibit B: Crushed rock core analyses from Juniper M-1.

STRATUM RESERVOIR

# SUMMARY OF VERTICAL CORE ANALYSES RESULTS

Drilling Fluid: Oil-Based Mud  Vacuum Dried at 180°F

Devon Energy Corporation
Juniper M-1 CCUS
WC

| Sample Number | Sample Top Depth, feet | Sample Bottom Depth, feet | Zone | 1st Net Confining Stress, psi | 2nd Net Confining Stress, psi | Permeability, millidarcys | | | | Porosity, percent | | | Grain Density, gm/cc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | to Air | | Klinkenberg | | | | | |
| | | | | | | NCS 1 | NCS 2 | NCS 1 | NCS 2 | Ambient | NCS 1 | NCS 2 | |
| 1-37 V | 8514.60 | 8514.80 | Morrison | 800 | 4000 | 0.0083 | 0.0002 | 0.0028 | <0.0001 | 5.1 | 5.0 | 4.4 | 2.70 |
| 1-60 V | 8537.40 | 8537.78 | Morrison | 800 | 4000 | 0.021 | 0.0097 | 0.0089 | 0.0034 | 9.7 | 9.6 | 9.3 | 2.65 |
| 1-91 V | 8568.15 | 8568.36 | Sundance | 800 | 4000 | 206. | 192. | 188. | 174. | 22.8 | 22.5 | 21.9 | 2.64 |
| 1-96 V | 8573.00 | 8573.41 | Sundance | 800 | 4000 | 284. | 264. | 262. | 242. | 24.2 | 24.1 | 23.7 | 2.64 |
| 1-99 V | 8576.60 | 8576.91 | Sundance | 800 | 4000 | 71.6 | 68.6 | 62.8 | 60. | 19.9 | 19.9 | 19.5 | 2.64 |
| 1-104 V | 8581.00 | 8581.40 | Sundance | 800 | 4000 | 87. | 83.4 | 76.8 | 73.5 | 21.1 | 20.8 | 20.2 | 2.64 |
| 1-108 V | 8585.00 | 8585.40 | Sundance | 800 | 4000 | 193. | 188. | 175. | 171. | 23.4 | 23.2 | 22.6 | 2.64 |
| 1-111 V | 8588.60 | 8589.00 | Sundance | 800 | 4000 | 33.8 | 30.1 | 28.6 | 25.3 | 19.8 | 19.6 | 19.0 | 2.64 |
| 1-115 V | 8592.60 | 8592.98 | Sundance | 800 | 4000 | 168. | 158. | 153. | 143. | 21.4 | 21.2 | 20.6 | 2.63 |
| 1-120 V | 8597.00 | 8597.42 | Sundance | 800 | 4000 | 146. | 139. | 132. | 125. | 21.8 | 21.7 | 21.1 | 2.63 |
| 2-4 V | 8601.00 | 8601.37 | Sundance | 800 | 4000 | 58.5 | 54.8 | 50.9 | 47.5 | 20.5 | 20.4 | 19.9 | 2.64 |
| 2-12 V | 8609.00 | 8609.30 | Sundance | 800 | 4000 | 52.3 | 48.6 | 45.2 | 41.9 | 21.3 | 21.0 | 20.5 | 2.64 |
| 2-16 V | 8613.00 | 8613.35 | Sundance | 800 | 4000 | 72.6 | 68. | 63.6 | 59.5 | 23.1 | 22.8 | 22.4 | 2.64 |
| 5-58 V | 9115.60 | 9115.98 | Goose Egg | 800 | 5000 | 0.081 | 0.0039 | 0.046 | 0.0011 | 4.3 | 4.1 | 3.5 | 2.72 |
| 5-62 V | 9119.00 | 9119.31 | Goose Egg | 800 | 5000 | 28.1 | 26.4 | 23.4 | 21.9 | 7.6 | 7.3 | 6.8 | 2.71 |
| 5-66 V | 9123.30 | 9123.68 | Goose Egg | 800 | 5000 | 0.059 | 0.003 | 0.031 | 0.0007 | 2.9 | 2.8 | 2.4 | 2.73 |
| 5-72 V | 9129.00 | 9129.34 | Goose Egg | 800 | 5000 | 13. | 11.7 | 10.6 | 9.52 | 6.6 | 6.4 | 6.0 | 2.71 |
| 5-76 V | 9133.20 | 9133.60 | Lyons | 800 | 5000 | 409. | 390. | 381. | 362. | 23.5 | 23.4 | 22.9 | 2.64 |
| 5-84 V | 9141.00 | 9141.35 | Lyons | 800 | 5000 | 1230. | 1180. | 1180. | 1130. | 24.7 | 24.5 | 24.0 | 2.64 |
| 5-87 V | 9144.70 | 9145.10 | Lyons | 800 | 5000 | 0.021 | 0.0097 | 0.0088 | 0.0034 | 6.4 | 6.2 | 5.8 | 2.72 |
| 6-4 V | 9150.10 | 9150.41 | Lyons | 800 | 5000 | 383. | 365. | 356. | 339. | 24.3 | 24.1 | 23.6 | 2.65 |
| 6-10 V | 9156.60 | 9157.04 | Lyons | 800 | 5000 | 290. | 276. | 267. | 255. | 21.5 | 21.4 | 20.9 | 2.66 |
| 6-16 V | 9162.60 | 9163.00 | Lyons | 800 | 5000 | 96.8 | 91.3 | 85.9 | 80.9 | 21.3 | 21.1 | 20.5 | 2.65 |
| 6-22 V | 9168.00 | 9168.40 | Lyons | 800 | 5000 | 3.12 | 2.59 | 2.45 | 2.03 | 13.0 | 12.8 | 12.3 | 2.69 |
| 6-26 V | 9172.40 | 9172.80 | Lyons | 800 | 5000 | 59.9 | 56.7 | 52.2 | 49.3 | 17.9 | 17.7 | 17.3 | 2.68 |
| 6-31 V | 9177.60 | 9178.00 | Lyons | 800 | 5000 | 0.0048 | 0.0018 | 0.0014 | 0.0004 | 1.7 | 1.6 | 1.4 | 2.73 |

STRATUM RESERVOIR

# SUMMARY OF VERTICAL CORE ANALYSES RESULTS

Drilling Fluid: Oil-Based Mud  Vacuum Dried at 180°F

Devon Energy Corporation
Juniper M-1 CCUS
WC

| Sample Number | Sample Top Depth, feet | Sample Bottom Depth, feet | Zone | 1st Net Confining Stress, psi | 2nd Net Confining Stress, psi | Permeability, millidarcys | | | | Porosity, percent | | | Grain Density, gm/cc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | to Air | | Klinkenberg | | | | | |
| | | | | | | NCS 1 | NCS 2 | NCS 1 | NCS 2 | Ambient | NCS 1 | NCS 2 | |

STRATUM RESERVOIR

# Crushed Rock Analysis
## Summary of Routine Crushed Core Analyses Results
As-Received and Vacuum Dried at 212°F

Devon Energy Corporation
Juniper M-1 CCUS
Laramie County, WY
WC Field

HH-112460
8/21/2023
7/25/2023

| Sample ID | Top Depth, feet | Bottom Depth, feet | A-R Bulk Density, gm/cc | A-R Grain Density, gms/cc | A-R Water Saturation, % of PV | A-R Oil Saturation, % of PV | A-R Gas Saturation, % of PV | A-R Gas Saturation, % of BV | *A-R Press Decay Permeability, md* | Dry Bulk Density, gm/cc | Dry Grain Density, gm/cc | Dry Helium Porosity, % of BV | *Dry Press Decay Permeability, md* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-2 CRA | 8479.30 | 8479.60 | 2.63 | 2.63 | 98.0 | 0.1 | 1.9 | 0.1 | *6.26E-06* | 2.56 | 2.75 | 6.8 | *7.70E-04* |
| 1-4 CRA | 8481.50 | 8481.90 | 2.61 | 2.62 | 98.4 | 0.4 | 1.2 | 0.1 | *5.14E-06* | 2.54 | 2.75 | 7.8 | *1.07E-03* |
| 1-10 CRA | 8487.65 | 8488.00 | 2.63 | 2.63 | 99.1 | 0.0 | 0.9 | 0.1 | *4.26E-06* | 2.56 | 2.75 | 7.1 | *8.82E-04* |
| 1-11 CRA | 8488.80 | 8489.20 | 2.62 | 2.62 | 99.0 | 0.2 | 0.8 | 0.1 | *3.25E-06* | 2.54 | 2.76 | 8.1 | *1.12E-03* |
| 1-20 CRA | 8497.65 | 8498.00 | 2.63 | 2.63 | 98.6 | 0.6 | 0.8 | 0.1 | *4.18E-06* | 2.54 | 2.77 | 8.3 | *1.22E-03* |
| 1-24 CRA | 8501.60 | 8502.00 | 2.63 | 2.64 | 99.1 | 0.2 | 0.7 | 0.1 | *3.16E-06* | 2.56 | 2.76 | 7.1 | *9.06E-04* |
| 1-32 CRA | 8509.70 | 8510.00 | 2.66 | 2.67 | 97.6 | 0.1 | 2.3 | 0.1 | *4.30E-06* | 2.62 | 2.73 | 4.0 | *4.17E-04* |
| 1-45 CRA | 8522.32 | 8522.75 | 2.67 | 2.68 | 95.4 | 0.2 | 4.4 | 0.1 | *7.84E-06* | 2.65 | 2.72 | 2.9 | *2.20E-04* |
| 1-51 CRA | 8528.00 | 8528.30 | 2.66 | 2.66 | 97.3 | 0.6 | 2.1 | 0.1 | *4.59E-06* | 2.63 | 2.72 | 3.2 | *3.10E-04* |
| 1-55 CRA | 8532.45 | 8532.75 | 2.65 | 2.69 | 81.1 | 1.5 | 17.4 | 1.4 | *6.59E-05* | 2.58 | 2.81 | 8.0 | *7.23E-04* |
| 1-57-1 CRA | 8534.70 | 8535.00 | 2.48 | 2.64 | 54.6 | 4.0 | 41.4 | 6.3 | *2.41E-04* | 2.39 | 2.82 | 15.3 | *9.97E-04* |
| 1-73 CRA | 8550.97 | 8551.40 | 2.62 | 2.63 | 87.6 | 1.2 | 11.2 | 0.7 | *3.72E-05* | 2.56 | 2.72 | 5.8 | *5.79E-04* |
| 1-75 CRA | 8552.65 | 8553.00 | 2.61 | 2.63 | 83.9 | 2.5 | 13.6 | 0.7 | *4.10E-05* | 2.57 | 2.72 | 5.4 | *5.21E-04* |
| 1-78 CRA | 8555.00 | 8555.35 | 2.61 | 2.62 | 85.7 | 6.1 | 8.2 | 0.5 | *2.52E-05* | 2.56 | 2.71 | 5.7 | *5.26E-04* |
| 1-79 CRA | 8556.55 | 8557.00 | 2.62 | 2.64 | 85.5 | 1.6 | 12.9 | 0.6 | *4.90E-05* | 2.58 | 2.71 | 4.8 | *3.84E-04* |
| *1-81 CRA** | 8558.30 | 8558.60 | | | | | | | | | | | |
| 2-43 CRA | 8640.60 | 8641.00 | 2.62 | 2.67 | 68.3 | 0.3 | 31.4 | 1.7 | *7.52E-05* | 2.58 | 2.73 | 5.4 | *4.60E-04* |
| 2-51 CRA | 8648.55 | 8649.00 | 2.67 | 2.69 | 82.2 | 0.3 | 17.5 | 0.7 | *4.21E-05* | 2.63 | 2.75 | 4.1 | *4.08E-04* |
| 2-60 CRA | 8657.43 | 8657.85 | 2.67 | 2.68 | 90.1 | 0.2 | 9.7 | 0.5 | *1.90E-05* | 2.63 | 2.76 | 4.8 | *1.23E-04* |
| 2-72 CRA | 8669.52 | 8670.00 | 2.68 | 2.69 | 88.5 | 0.1 | 11.4 | 0.5 | *2.57E-05* | 2.63 | 2.76 | 4.6 | *5.83E-04* |
| 2-81 CRA | 8678.60 | 8679.00 | 2.69 | 2.69 | 93.2 | 0.1 | 6.7 | 0.3 | *1.76E-05* | 2.64 | 2.77 | 4.5 | *4.60E-04* |
| 2-91 CRA | 8688.60 | 8689.00 | 2.71 | 2.73 | 80.2 | 1.4 | 18.4 | 0.5 | *3.08E-05* | 2.69 | 2.77 | 2.8 | *2.14E-04* |
| 2-116 CRA | 8713.45 | 8713.85 | 2.69 | 2.69 | 94.8 | 0.1 | 5.1 | 0.2 | *8.55E-06* | 2.64 | 2.76 | 4.3 | *3.31E-04* |
| 2-128 CRA | 8725.30 | 8725.70 | 2.69 | 2.69 | 92.7 | 0.1 | 7.2 | 0.3 | *1.27E-05* | 2.64 | 2.76 | 4.3 | *2.67E-04* |
| 2-136 CRA | 8733.00 | 8733.40 | 2.69 | 2.70 | 97.1 | 0.0 | 2.9 | 0.1 | *6.29E-06* | 2.64 | 2.78 | 4.8 | *4.26E-04* |
| 2-151 CRA | 8748.20 | 8748.60 | 2.71 | 2.71 | 97.4 | 0.2 | 2.4 | 0.1 | *4.53E-06* | 2.67 | 2.79 | 4.3 | *9.48E-05* |
| *2-162 CRA** | 8759.45 | 8759.85 | | | | | | | | | | | |
| 2-174 CRA | 8771.20 | 8771.60 | 2.69 | 2.70 | 96.3 | 0.0 | 3.7 | 0.2 | *7.67E-06* | 2.65 | 2.76 | 4.2 | *3.02E-04* |
| 2-194 CRA | 8791.00 | 8791.40 | 2.69 | 2.69 | 97.4 | 0.2 | 2.4 | 0.1 | *4.40E-06* | 2.65 | 2.75 | 3.8 | *7.64E-05* |
| 2-207 CRA | 8804.00 | 8804.46 | 2.70 | 2.71 | 98.7 | 0.2 | 1.1 | 0.1 | *2.84E-06* | 2.65 | 2.79 | 5.0 | *3.94E-04* |
| 3-11 CRA | 8817.60 | 8818.00 | 2.74 | 2.74 | 98.2 | 0.2 | 1.6 | 0.1 | *2.13E-06* | 2.70 | 2.79 | 3.1 | *2.52E-04* |
| 3-24 CRA | 8830.55 | 8830.95 | 2.70 | 2.70 | 98.9 | 0.0 | 1.1 | 0.1 | *3.32E-06* | 2.64 | 2.80 | 5.7 | *6.78E-04* |
| 3-33 CRA | 8839.45 | 8839.85 | 2.71 | 2.71 | 95.3 | 0.1 | 4.6 | 0.2 | *9.08E-06* | 2.66 | 2.79 | 4.5 | *1.40E-04* |
| *3-42 CRA** | 8848.05 | 8848.45 | | | | | | | | | | | |
| 3-51 CRA | 8857.50 | 8857.90 | 2.67 | 2.67 | 98.7 | 0.2 | 1.1 | 0.1 | *2.98E-06* | 2.61 | 2.77 | 5.9 | *6.86E-04* |
| 3-57 CRA | 8863.30 | 8863.75 | 2.70 | 2.70 | 98.6 | 0.3 | 1.1 | 0.1 | *2.67E-06* | 2.66 | 2.78 | 4.4 | *3.99E-04* |
| 3-61 CRA | 8867.50 | 8867.90 | 2.72 | 2.72 | 98.7 | 0.1 | 1.2 | 0.1 | *2.35E-06* | 2.68 | 2.79 | 4.2 | *4.40E-04* |
| *3-66 CRA* | *8872.30* | *8872.71* | 2.93 | 2.94 | *76.8* | *2.2* | *21.0* | 0.1 | *2.50E-06* | 2.93 | 2.94 | 0.4 | *1.33E-05* |
| 3-75 CRA | 8881.15 | 8881.55 | 2.70 | 2.71 | 91.8 | 0.2 | 8.0 | 0.3 | *1.55E-05* | 2.66 | 2.76 | 3.7 | *3.35E-04* |
| 3-85 CRA | 8891.20 | 8891.65 | 2.73 | 2.73 | 96.1 | 0.1 | 3.8 | 0.1 | *3.28E-06* | 2.70 | 2.77 | 2.5 | *1.32E-04* |
| 3-89 CRA | 8895.50 | 8895.90 | 2.69 | 2.70 | 98.9 | 0.1 | 1.0 | 0.1 | *3.48E-06* | 2.64 | 2.77 | 4.9 | *4.31E-04* |
| 3-97 CRA | 8903.60 | 8904.00 | 2.69 | 2.69 | 98.1 | 0.2 | 1.7 | 0.1 | *3.49E-06* | 2.64 | 2.76 | 4.3 | *3.84E-04* |
| 3-101 CRA | 8907.10 | 8907.55 | 2.94 | 2.94 | *89.1* | *0.5* | *10.4* | 0.1 | *2.91E-06* | 2.94 | 2.95 | 0.5 | *1.87E-05* |
| 3-110 CRA | 8916.10 | 8916.55 | 2.68 | 2.69 | 98.7 | 0.0 | 1.3 | 0.1 | *2.37E-06* | 2.64 | 2.75 | 4.2 | *2.96E-04* |
| *3-120 CRA* | *8926.00* | *8926.40* | 2.95 | 2.95 | *83.5* | *0.3* | *16.2* | 0.1 | *1.81E-06* | 2.94 | 2.95 | 0.3 | *9.42E-06* |
| 3-124 CRA | 8930.40 | 8930.80 | 2.66 | 2.66 | 98.9 | 0.2 | 0.9 | 0.1 | *2.66E-06* | 2.59 | 2.75 | 6.1 | *5.42E-04* |
| *3-132 CRA* | *8938.15* | *8938.60* | 2.95 | 2.95 | *51.9* | *0.6* | *47.5* | 0.1 | *2.43E-06* | 2.95 | 2.95 | 0.2 | *7.43E-06* |
| 3-134 CRA | 8940.60 | 8941.00 | 2.67 | 2.68 | 99.3 | 0.0 | 0.7 | 0.1 | *2.22E-06* | 2.59 | 2.80 | 7.7 | *7.58E-04* |
| *3-140 CRA* | *8946.60* | *8947.00* | 2.91 | 2.92 | *64.4* | *1.3* | *34.3* | 0.2 | *6.15E-06* | 2.91 | 2.93 | 0.6 | *1.71E-05* |
| *3-150 CRA* | *8956.00* | *8956.40* | 2.93 | 2.94 | *69.4* | *1.8* | *28.8* | 0.1 | *3.00E-06* | 2.93 | 2.94 | 0.3 | *8.82E-06* |
| 3-152 CRA | 8958.10 | 8958.50 | 2.73 | 2.73 | 98.9 | 0.2 | 0.9 | 0.1 | *2.40E-06* | 2.67 | 2.83 | 5.9 | *4.87E-04* |
| *3-158 CRA* | *8964.50* | *8964.90* | 2.94 | 2.94 | *85.5* | *0.5* | *14.0* | 0.1 | *1.90E-06* | 2.93 | 2.95 | 0.4 | *1.68E-05* |

STRATUM RESERVOIR

# Crushed Rock Analysis
## Summary of Routine Crushed Core Analyses Results
As-Received and Vacuum Dried at 212°F

Devon Energy Corporation
Juniper M-1 CCUS
Laramie County, WY
WC Field

HH-112460
8/21/2023
7/25/2023

| Sample ID | Top Depth, feet | Bottom Depth, feet | A-R Bulk Density, gm/cc | A-R Grain Density, gms/cc | A-R Water Saturation, % of PV | A-R Oil Saturation, % of PV | A-R Gas Saturation, % of PV | A-R Gas Saturation, % of BV | *A-R Press Decay Permeability, md* | Dry Bulk Density, gm/cc | Dry Grain Density, gm/cc | Dry Helium Porosity, % of BV | *Dry Press Decay Permeability, md* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4-1 CRA | 8970.20 | 8970.60 | 2.71 | 2.72 | 97.2 | 0.6 | 2.2 | 0.1 | *5.76E-06* | 2.67 | 2.78 | 3.7 | *3.37E-04* |
| 4-3 CRA | 8972.15 | 8972.50 | 2.76 | 2.76 | 92.5 | 0.1 | 7.4 | 0.1 | *6.89E-06* | 2.74 | 2.79 | 1.8 | *4.88E-05* |
| *4-9 CRA* | *8978.30* | *8978.70* | 2.94 | 2.94 | *65.4* | *0.7* | *33.9* | 0.1 | *4.04E-06* | 2.94 | 2.95 | 0.3 | *1.14E-05* |
| 4-27 CRA | 8996.00 | 8996.30 | 2.78 | 2.79 | 79.4 | 0.2 | 20.4 | 0.5 | *2.93E-05* | 2.76 | 2.82 | 2.3 | *9.29E-05* |
| *4-33 CRA* | *9002.60* | *9003.00* | 2.94 | 2.94 | *83.1* | *2.3* | *14.6* | 0.1 | *2.97E-06* | 2.93 | 2.94 | 0.4 | *1.51E-05* |
| 4-44 CRA | 9013.35 | 9013.75 | 2.59 | 2.59 | 99.5 | 0.0 | 0.5 | 0.1 | *3.16E-06* | 2.45 | 2.80 | 12.5 | *5.19E-04* |
| *4-56 CRA* | *9025.60* | *9026.00* | 2.93 | 2.94 | *44.5* | *6.1* | *49.4* | 0.3 | *1.43E-05* | 2.93 | 2.94 | 0.6 | *2.59E-05* |
| *4-60 CRA* | *9029.40* | *9029.85* | 2.91 | 2.92 | *69.1* | *2.9* | *28.0* | 0.2 | *7.50E-06* | 2.90 | 2.93 | 0.8 | *4.72E-05* |
| 4-70 CRA | 9039.55 | 9040.00 | 2.65 | 2.68 | 76.4 | 0.0 | 23.6 | 1.0 | *4.63E-05* | 2.62 | 2.73 | 4.1 | *2.05E-04* |
| 4-79 CRA | 9048.30 | 9048.70 | 2.67 | 2.69 | 87.4 | 0.0 | 12.6 | 0.4 | *1.52E-05* | 2.64 | 2.73 | 3.3 | *1.37E-04* |
| 5-5 CRA | 9062.60 | 9063.00 | 2.64 | 2.65 | 98.4 | 0.0 | 1.6 | 0.1 | *3.73E-06* | 2.57 | 2.75 | 6.3 | *4.34E-04* |
| 5-7 CRA | 9064.15 | 9064.55 | 2.68 | 2.69 | 97.3 | 0.1 | 2.6 | 0.2 | *8.46E-06* | 2.61 | 2.79 | 6.4 | *5.90E-04* |
| 5-23 CRA | 9080.60 | 9081.00 | 2.64 | 2.64 | 99.5 | 0.0 | 0.5 | 0.1 | *2.31E-06* | 2.51 | 2.82 | 11.1 | *7.53E-04* |
| 5-33 CRA | 9090.35 | 9090.75 | 2.50 | 2.50 | 99.7 | 0.0 | 0.3 | 0.1 | *1.78E-06* | 2.32 | 2.75 | 15.7 | *8.99E-04* |
| 5-45 CRA | 9102.60 | 9103.00 | 2.66 | 2.66 | 99.5 | 0.0 | 0.5 | 0.1 | *2.12E-06* | 2.53 | 2.84 | 11.1 | *7.27E-04* |
| *5-46 CRA* | *9103.60* | *9104.00* | 2.94 | 2.94 | *81.9* | *0.8* | *17.3* | 0.1 | *2.18E-06* | 2.94 | 2.95 | 0.3 | *1.25E-05* |
| *5-52 CRA* | *9109.40* | *9109.80* | 2.72 | 2.74 | *22.7* | *2.5* | *74.8* | 0.5 | *8.82E-06* | 2.72 | 2.74 | 0.7 | *1.28E-05* |
| 6-37 CRA | 9183.95 | 9184.30 | 2.67 | 2.67 | 98.6 | 0.1 | 1.3 | 0.1 | *4.36E-06* | 2.60 | 2.77 | 6.4 | *4.16E-04* |
| 6-47 CRA | 9193.50 | 9193.85 | 2.68 | 2.68 | 98.1 | 1.0 | 0.9 | 0.1 | *3.51E-06* | 2.61 | 2.77 | 5.6 | *3.72E-04* |
| 6-57 CRA | 9203.00 | 9203.45 | 2.67 | 2.67 | 97.9 | 0.7 | 1.4 | 0.1 | *4.47E-06* | 2.61 | 2.74 | 4.7 | *3.79E-04* |
| 6-66 CRA | 9212.00 | 9212.45 | 2.67 | 2.67 | 98.5 | 0.5 | 1.0 | 0.1 | *2.71E-06* | 2.61 | 2.75 | 5.2 | *5.45E-04* |
| 6-74 CRA | 9220.30 | 9220.85 | 2.69 | 2.69 | 99.0 | 0.0 | 1.0 | 0.1 | *2.73E-06* | 2.63 | 2.77 | 5.3 | *6.01E-04* |
| 6-86 CRA | 9232.00 | 9232.45 | 2.72 | 2.73 | 92.9 | 0.2 | 6.9 | 0.3 | *1.74E-05* | 2.67 | 2.81 | 4.9 | *4.23E-04* |
| 6-93 CRA | 9239.55 | 9239.95 | 2.65 | 2.66 | 98.2 | 0.0 | 1.8 | 0.1 | *4.17E-06* | 2.60 | 2.74 | 5.1 | *1.72E-04* |
| 6-112 CRA | 9258.00 | 9258.40 | 2.67 | 2.68 | 92.6 | 0.1 | 7.3 | 0.4 | *2.50E-05* | 2.60 | 2.77 | 6.1 | *7.44E-04* |
| 6-117 CRA | 9263.00 | 9263.40 | 2.67 | 2.68 | 89.8 | 0.0 | 10.2 | 0.4 | *1.31E-05* | 2.64 | 2.74 | 3.7 | *1.71E-04* |
| Average values: | | | 2.71 | 2.72 | 89.2 | 0.7 | 10.2 | 0.3 | *1.44E-05* | 2.66 | 2.79 | 4.7 | *3.94E-04* |

As-received bulk volumes and bulk densities were determined on intact bulk sample material. The bulk material was crushed and all other analysis reported herein were conducted on the crushed material.
The following brine & oil densities were used to calculate brine & oil volumes respectively: For samples 1-2 CRA-1-81 CRA 1.001g/cc; 2-43 CRA-3-61 CRA 1.045g/cc; 3-66 CRA-6-112 CRA 1.164g/cc & 0.825g/cc.
*% Fluid Sat's calculation in these samples based on relatively low or limited volumetrics; pore volume <1.00cc. Some values may be suspect.*
Mud/Fluid type: OBM

*Permeabilities calculated using CSM mathematics.*
**These samples are still processing and will be reported at a later date.*

# APPENDIX I—WELLS UTILIZED IN GEOCELLULAR MODELING

Table H.1—SE WY Model: Petrophysics

| Name | API # | State | Latitude | Longitude | Well Datum (ft) | TD (ft, TVDSS) | TD (ft, MD) |
|---|---|---|---|---|---|---|---|
| BASTIAN 1-21 | 4902120398 | WY | 41.250165 | -104.312383 | 5,489 | -4,722 | 10,211 |
| BERRY 1-32 | 2610522505 | NE | 41.14564901 | -103.991181 | 5,228 | -4,072 | 9,300 |
| CHAMPLIN 318 AMOCO B-1 | 4902120231 | WY | 41.243153 | -104.341498 | 5,502 | -5,298 | 10,800 |
| CLARK 1-3 | 0512314188 | CO | 40.778984 | -104.313003 | 5,006 | -5,024 | 10,030 |
| COMPTON 1 | 2610521766 | NE | 41.308334 | -104.008978 | 5,160 | -4,811 | 9,971 |
| DF RANCH 1161-21-42 | 0512330025 | CO | 40.904986 | -104.207434 | 5,254 | -3,821 | 9,075 |
| ENDERSON 31-14 | 0512331745 | CO | 40.960755 | -104.023565 | 5,436 | -4,044 | 9,480 |
| HOTTELL 1-14HW | 2610522432 | NE | 41.18971701 | -103.943006 | 5,002 | -4,330 | 9,332 |
| HUTCHINSON-HIEBER 1 | 4902120399 | WY | 41.246787 | -104.332658 | 5,452 | -4,844 | 10,296 |
| Juniper M-1 | 4902129548 | WY | 41.055968 | -104.271948 | 5,352 | -4,472 | 9,824 |
| LOUTH GEORGE 1 | 4902120259 | WY | 41.24313 | -104.274511 | 5,424 | -4,605 | 10,029 |
| MILLER 1-18 | 4902120252 | WY | 41.088249 | -104.47688 | 5,661 | -4,151 | 9,812 |
| NOVOTNY 22-2 | 2610522642 | NE | 41.04326701 | -103.905735 | 5,266 | -4,537 | 9,803 |
| SWD C8A | 0512332858 | CO | 40.893947 | -104.335021 | 5,196 | -5,361 | 10,557 |
| UPRR-PALM 1-21 | 4902120254 | WY | 41.073211 | -104.3239 | 5,430 | -3,994 | 9,424 |
| SIMBA 1-06 SWD | 0512331035 | CO | 40.955647 | -104.361223 | 5,374 | -4,145 | 9,520 |
| NGL C9 SWD | 0512340194 | CO | 40.835985 | -104.159846 | 5,073 | -5,127 | 10,200 |

Table H.2—SE WY Model: Lyons Wells

| Name | API # | State | Latitude | Longitude | Well Datum (ft) | TD (ft, TVDSS) | TD (ft, MD) |
|---|---|---|---|---|---|---|---|
| BALL 16-14 | 0512305560 | CO | 40.658592 | -104.409339 | 4,959 | -3,881 | 8,840 |
| BASTIAN 1-21 | 4902120398 | WY | 41.250165 | -104.312383 | 5,489 | -4,722 | 10,211 |
| BERANEK 43-28 | 2610522757 | NE | 41.152169 | -103.969298 | 5,122 | -14,878 | 20,000 |
| BERRY 1-32 | 2610522505 | NE | 41.145649 | -103.991181 | 5,228 | -4,072 | 9,300 |
| BIG SANDY 132-33M | 4902121011 | WY | 41.136375 | -104.669623 | 5,919 | -4,727 | 10,646 |
| BOLTON 36-22D | 4902120588 | WY | 41.31117 | -104.144921 | 5,328 | -3,680 | 9,008 |
| CHAMPLIN 318 AMOCO B-1 | 4902120231 | WY | 41.243153 | -104.341498 | 5,502 | -5,298 | 10,800 |
| CHAMPLIN564 AMOCO A 1 | 4902120229 | WY | 41.311119 | -104.135312 | 5,313 | -5,037 | 10,350 |
| CLARK 1-3 | 0512314188 | CO | 40.778984 | -104.313003 | 5,006 | -5,024 | 10,030 |
| COLORADO STATE-A 1 | 0512311469 | CO | 40.850686 | -104.525135 | 5,313 | -5,487 | 10,800 |
| COMPTON 1 | 2610521766 | NE | 41.308334 | -104.008978 | 5,160 | -4,811 | 9,971 |
| CON GQ 07-01 | 0512335654 | CO | 40.854269 | -104.241835 | 5,091 | -5,290 | 10,381 |

| Name | API # | State | Latitude | Longitude | Well Datum (ft) | TD (ft, TVDSS) | TD (ft, MD) |
|---|---|---|---|---|---|---|---|
| COONEY 13-33 | 4902120910 | WY | 41.30759 | -104.098882 | 5,298 | -4,468 | 9,766 |
| COX 1-A | 0512305906 | CO | 40.947017 | -104.579282 | 5,696 | -4,504 | 10,200 |
| CROISSANT 1 | 0512321426 | CO | 40.724943 | -104.289341 | 5,016 | -3,784 | 8,800 |
| CROISSANT 4 | 0512321651 | CO | 40.724412 | -104.293799 | 5,022 | -3,778 | 8,800 |
| DF RANCH 1161-21-42 | 0512330025 | CO | 40.904986 | -104.207434 | 5,254 | -3,821 | 9,075 |
| DUNBAR 1 | 0512323247 | CO | 40.773342 | -104.213329 | 5,025 | -3,591 | 8,616 |
| DUNBAR 2 | 0512323778 | CO | 40.776316 | -104.216516 | 5,047 | -3,614 | 8,661 |
| DUNBAR 3 | 0512323849 | CO | 40.776503 | -104.211226 | 5,056 | -4,373 | 9,429 |
| EHMKE 1 | 0512307161 | CO | 40.867315 | -104.0034 | 5,266 | -3,389 | 8,655 |
| ENDERSON 31-14 | 0512331745 | CO | 40.960755 | -104.023565 | 5,436 | -4,044 | 9,480 |
| EWS 9 | 0512350644 | CO | 40.945367 | -104.393089 | 5,293 | -14,707 | 20,000 |
| EWS 9A | 0512350645 | CO | 40.945447 | -104.393089 | 5,293 | -14,707 | 20,000 |
| FRANKS 2 | 0512310091 | CO | 40.699524 | -104.208093 | 4,980 | -3,524 | 8,504 |
| FRITZ 1 | 4902105033 | WY | 41.137789 | -104.141819 | 5,208 | -3,807 | 9,015 |
| GIBBS 1 | 0512305608 | CO | 40.714192 | -104.217521 | 4,982 | -3,532 | 8,514 |
| GILLETTE 14 | 0512305696 | CO | 40.769471 | -104.216361 | 5,014 | -3,536 | 8,550 |
| GILLETTE LOIS 1 | 0512322125 | CO | 40.769346 | -104.218156 | 5,022 | -3,557 | 8,579 |
| GOVT 1-18 | 0512307208 | CO | 40.754829 | -104.02771 | 5,126 | -3,254 | 8,380 |
| GRACE-MARATHON 3-1 | 0512310136 | CO | 40.695283 | -104.307548 | 4,991 | -3,799 | 8,790 |
| GRAEFE 1R | 0512306129 | CO | 40.721226 | -104.293921 | 5,017 | -3,783 | 8,800 |
| HILLMAN 9-1 | 0512331744 | CO | 40.857176 | -103.975976 | 5,117 | -3,261 | 8,378 |
| HOTTELL 1-14HW | 2610522432 | NE | 41.189717 | -103.943006 | 5,002 | -4,330 | 9,332 |
| HUTCHINSON-HIEBER 1 | 4902120399 | WY | 41.246787 | -104.332658 | 5,452 | -4,844 | 10,296 |
| Juniper M-1 | 4902129548 | WY | 41.055968 | -104.271948 | 5,352 | -4,472 | 9,824 |
| JUBILEE 230-2311H | 4902121468 | WY | 41.086019 | -104.633342 | 5,926 | -5,846 | 11,772 |
| JUBILEE 700-22M | 4902121517 | WY | 41.074744 | -104.642228 | 5,930 | -4,719 | 10,650 |
| KLINGINSMITH 1 | 0512305907 | CO | 40.948613 | -103.917314 | 5,237 | -4,701 | 9,938 |
| LOUTH GEORGE 1 | 4902120259 | WY | 41.24313 | -104.274511 | 5,424 | -4,605 | 10,029 |
| LUCKY LADY 16-4 | 0512314635 | CO | 40.840371 | -104.103521 | 5,511 | -3,439 | 8,950 |
| MARICK 7-29 | 0512323360 | CO | 40.894826 | -104.226474 | 5,173 | -3,698 | 8,871 |
| MCVICAR-GOVT 1 | 0512305753 | CO | 40.808367 | -104.360228 | 5,080 | -3,927 | 9,007 |
| MILES & DON GILLETT 8 | 0512305698 | CO | 40.768849 | -104.217673 | 5,016 | -4,647 | 9,663 |
| MILES & GILLETT 9 | 0512305683 | CO | 40.761629 | -104.208104 | 5,004 | -3,522 | 8,526 |
| MILLER 1-18 | 4902120252 | WY | 41.088249 | -104.47688 | 5,661 | -4,151 | 9,812 |
| NGL C8C | 0512351112 | CO | 40.893867 | -104.335011 | 5,186 | -14,814 | 20,000 |
| NGL C9B | 0512340770 | CO | 40.826515 | -104.144666 | 5,084 | -4,866 | 9,950 |

| Name | API # | State | Latitude | Longitude | Well Datum (ft) | TD (ft, TVDSS) | TD (ft, MD) |
|---|---|---|---|---|---|---|---|
| NOVOTNY 22-2 | 2610522642 | NE | 41.043267 | -103.905735 | 5,266 | -4,537 | 9,803 |
| PERCY PERRY 1 | 0512305653 | CO | 40.751171 | -104.16039 | 4,991 | -3,525 | 8,516 |
| PURDY FARMS 1 | 2610522769 | NE | 41.088797 | -103.922797 | 5,212 | -14,788 | 20,000 |
| RAZOR 21 SWD 1 | 0512340777 | CO | 40.823872 | -103.86878 | 4,842 | -3,708 | 8,550 |
| RENSICK 1 | 0512305613 | CO | 40.72101 | -104.303595 | 5,027 | -3,720 | 8,747 |
| SCHEEL 1 | 4902120124 | WY | 41.318905 | -104.17402 | 5,363 | -3,903 | 9,266 |
| SCHEETZ ARTHUR 1 | 0512305702 | CO | 40.769196 | -104.208116 | 5,012 | -3,499 | 8,511 |
| SHARK FEDERAL 1 | 0512311747 | CO | 40.684752 | -104.412077 | 4,983 | -4,021 | 9,004 |
| SOHIO-STATE 2 | 0512307185 | CO | 40.707135 | -104.150876 | 4,950 | -3,550 | 8,500 |
| STATE 1-16 | 0512307196 | CO | 40.744144 | -104.104126 | 5,044 | -3,516 | 8,560 |
| STATE 13-36 | 0512309934 | CO | 40.786616 | -104.274375 | 5,020 | -3,740 | 8,760 |
| STEINKE-GILLETTE 2 | 0512305700 | CO | 40.768729 | -104.227204 | 4,996 | -3,532 | 8,528 |
| STRASSER 1 | 0512307198 | CO | 40.726643 | -104.07062 | 4,996 | -3,356 | 8,352 |
| SWD C8A | 0512332858 | CO | 40.893947 | -104.335021 | 5,196 | -5,361 | 10,557 |
| TOEDTLI 1-10 | 0512315385 | CO | 40.851415 | -103.739131 | 4,791 | -4,384 | 9,175 |
| UPRR-PALM 1-21 | 4902120254 | WY | 41.073211 | -104.3239 | 5,430 | -3,994 | 9,424 |
| W C BACHOR 1A | 0512312968 | CO | 40.771444 | -104.222135 | 5,014 | -3,536 | 8,550 |
| WELD COUNTY 1 | 0512305752 | CO | 40.806659 | -104.146717 | 5,256 | -3,565 | 8,821 |
| WEST 11-24 | 0512325585 | CO | 40.652504 | -104.274362 | 5,028 | -3,701 | 8,729 |
| WILLIAMSON 2 | 0512305685 | CO | 40.761499 | -104.217624 | 4,987 | -3,539 | 8,526 |
| SIMBA 1-06 SWD | 0512331035 | CO | 40.955647 | -104.361223 | 5,374 | -4,145 | 9,520 |
| NGL C9 SWD | 0512340194 | CO | 40.835985 | -104.159846 | 5,073 | -5,127 | 10,200 |
| NGL C9C SWD | 0512340771 | CO | 40.820625 | -104.161956 | 5,090 | -5,010 | 10,100 |
| SWD C8B | 0512332860 | CO | 40.893797 | -104.335011 | 5,191 | -5,662 | 11,371 |
| BALL 16-14 | 0512305560 | CO | 40.658592 | -104.409339 | 4,959 | -3,881 | 8,840 |

# APPENDIX J—EXAMPLE MUD ACID PROGRAM

**Spirea I-1 - Proposed Stimulation Plan [WWQR, Chapter 24, Section 10 (b)(xx)]**

Introduction

Matrix stimulation is the process of injecting a fluid (acid or solvent) into an existing or newly completed well below the fracturing pressure to remove or bypass damage. This technique is very common and has been used extensively to improve production or injection rates. The primary goal of matrix stimulation in sandstones is to restore the natural permeability, i.e., to obtain the undamaged flow capacity, in the injection zone by removing the formation damage. Dramatic rate-increasing results may be achieved via matrix stimulation if treatments are properly engineered, which includes tasks done within a predefined methodology, Matrix Stimulation Engineering (MSE), the practical application of scientific and mathematical principles to matrix stimulation. The MSE process steps are:

- Formation Damage Determination
- Fluid Selection
- Treatment Design
- Execution
- Treatment Evaluation

The matrix stimulation process for the Project includes at least two time periods – once prior to the beginning of the injection, at least once during the injection period; latter to be determined based on injection performance and routine analysis.

Procedure

*Pre-Injection Stimulation*

The stimulation practice prior to beginning injection is to remove existing damage from drilling and completion fluids that reduces injectivity performance of the well. This step is usually carried out using acid or non-acid based systems containing dispersant-type surfactants and chelating agents to remove mud solids from the critical matrix region. The methods and materials used in the Project will follow preapproved methodologies materials provided by the Wyoming Oil and Gas Conservation Commission. Since the Lyons Sandstone is not considered to be acid sensitive, an acid-based system, predominantly hydrochloric acid (HCl) is recommended to remove damage prior to $CO_2$ injection. This system also provides a secondary benefit of cleaning up the wellbore and/or perforations prior to the subsequent matrix stimulation treatment. Additional surfactant and chelating additives are very effective in dispersing and suspending solids causing damage to the injection zone. A pre- and post-treatment injection test will help determine the effectiveness of the matrix stimulation treatment. If the executed treatment is not successful in removing the

damage, a mud acid based system, which is a combination of HCl and hydrofluoric acid (HF) with compatible surfactant and chelating agents can be pumped. A preflush will be pumped, in this case, to minimize formation damage from fluorosilicates, as explained below.

*During-Injection Stimulation*

Matrix stimulation using various acid systems, HCl, mud acid, and clay acid, can remove existing damage and restore injectivity. Mud acid is used primarily to restore permeability due to precipitation and/or fines migration. The design of mud acid is critical for an effective stimulation treatment, due to potential secondary and tertiary reactions. Insoluble precipitation of calcium or magnesium fluoride F-3 from reaction with limestone and dolomite can reduce permeability. For this reason, a preflush of 5-15% HCl is normally pumped to dissolve these minerals. Mud acid is represented as a ratio of HCl-HF, with regular mud acid being 12% HCl + 3% HF.

The treatment sequence of the stimulation treatment and its purpose is detailed below:

1. Ammonium chloride-formation water displacement, generally ranging from 15-75 gal US/ft.
2. HCl preflush – dissolve calcareous materials before introducing HF. Typically ranging from 10-250 gal US/ft.
3. Mud acid – remove formation damage and restore permeability in the critical area of the wellbore, generally ranging from 10 to 250 gal US/net ft.
4. Ammonium chloride overflush – displaces the HF phase away from the wellbore so that any precipitants occur at a significant distance from the near-wellbore region, where the effect on injectivity will be insignificant. Generally, the overflush is 10 to 250 gal US/ft and is 2%–8% $NH_4Cl$.

# APPENDIX K—NOTIFICATION LIST

**NOTIFICATION LIST**
**Spirea**
**Laramie County, Wyoming**
**Weld County, Colorado**

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| T12N - R62W<br>Sec. 6: Lots 1, 2 , S2NE, less fractional part of Lot 2 & S2NE | James L. Rodebaugh & Maria J. Rodebaugh, hw | 4875 County Road 203 | Carpenter | WY | 82054 | SI / MI |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| T12N - R62W<br>Sec. 6: Fractional Part of Lot 2 and S2NE | Paul Arthur Auclair | 4859 Road 203 | Carpenter | WY | 82054 | SI / MI |
| | David John Leastman II | 320 5th Street | Carpenter | WY | 82054 | SI |
| | David Brookens | 556 Central Avenue | Beach | ND | 58621 | SI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | TARH E&P Holdings, L.P. | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1100 | Denver | CO | 80202 | ORRI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Mark Klingseisen | 2305A Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5815 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T12N - R62W<br>Sec. 6: Lots 3, 4, 5, SENW | Abram Landis Derstine & Annette Marie Destine, HW, TBE | 215 County Road 148 | Carpenter | WY | 82054 | SI |
| | Patrick Rehwinkel | 13500 Road W | Weldona | CO | 80653 | MI |
| | Peter Rehwinkel | 13500 Road W | Weldona | CO | 80653 | MI |
| | Jonna Rehwinkel Lewis | 13500 Road W | Weldona | CO | 80653 | MI |
| | Heidi Rehwinkel Moore | 13500 Road W | Weldona | CO | 80653 | MI |
| | David M. Jesse | 51 Eldred | Bedford | OH | 44146 | MI |
| | Richard Jesse | 3120 Carefree Highway 1538 | Phoenix | AZ | 85086 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | TARH E&P Holdings, L.P. | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1100 | Denver | CO | 80202 | ORRI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Julian Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Mark Klingseisen | 2305A Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5815 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | US West Communications, Inc. | 7800 East Orchard Suite 480 | Englewood | CO | 80111 | ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R62W<br>Sec. 6: Lots 6, 7, E2SW | Clayton Derstine & Sonya Derstine, hw | P.O. Box 358 | Carpenter | WY | 82054 | SI / MI |
| | Abram Landis Derstine & Annette Marie Destine, HW, TBE | 215 County Road 148 | Carpenter | WY | 82054 | SI |
| | Zandra A. Harper | P.O. Box 366 | Carpenter | WY | 82054 | SI |
| | Bill Barrett Corporation | 1099 18th Street, Suite 2300 | Denver | CO | 80202 | MI |
| | Marion E. Estes & William A. Estes, wh | 575 Long Lane | Casper | WY | 82609 | MI |
| | Elizabeth L. Willoughby & Robert F. Willoughby, wh | 142 Flagstaff Way | Buffalo | WY | 82834 | MI |
| | Ruth V. Willoughby | 215 South Third Avenue | Casper | WY | 82601 | MI |
| | Barry S. Farris & Gralyn J. Farris, hw | 1544 South Pitkin Circle | Aurora | CO | 80017 | MI |
| | Jeffrey B. Farris & Mary Ann Farris, hw | P.O. Box 751 | Byers | CO | 80103 | MI |
| | Michael B. Farris, a single man | P.O. Box 751 | Byers | CO | 80103 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Springfield Oil Company | 27619 Brook Drive | Hot Springs | SD | 57747 | WI |
| | TARH E&P Holdings, L.P. | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1100 | Denver | CO | 80202 | ORRI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Julian Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Mark Klingseisen | 2305A Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5815 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Blue Federal Credit Union | P.O. Box 3200 | Cheyenne | WY | 82003 | MTG |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R62W | Leo Smith and Janet Smith | 115 Road 153 | Carpenter | WY | 82054 | SI / MI |
| Sec. 6: SE | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | TARH E&P Holdings, L.P. | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1100 | Denver | CO | 80202 | ORRI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Julian Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Mark Klingseisen | 2305A Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5815 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | US West Communications, Inc. | 7800 East Orchard Suite 480 | Englewood | CO | 80111 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R62W | Leo Smith and Janet Smith | 115 Road 153 | Carpenter | WY | 82054 | SI |
| Sec. 7: NE | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| | BNSF Railway Company | 2650 Lou Menk Drive | Fort Worth | TX | 76131-2830 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W | Emmanuel Farm LLP | 220 Road 148 | Carpenter | WY | 82054 | SI |
| Sec. 7: Lots 1, 2, E2NW | Todd Alan Martin and Sydnee Marie Martin as Co-Trustees of the Todd Alan Martin and Sydnee Marie Martin Marital Trust u/t/a dated 11-21-2019 | 169 County Road 148 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Clear Creek Resource Partners | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W | Cindy I. Johnston, Trustee under the | 609 Artesian Road | Cheyenne | WY | 82007 | SI |
| Sec. 7: Lots 3, 4, E2SW | Mike Poelma and Caroline Poelma, Trustees of the Mike Poelma Living Trust dated 08-17-2011 and the Caroline Poelma Living Trust dated 08-17-2011 | 5296 Road 202 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Clear Creek Resource Partners | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W<br>Sec. 7: SE | Gilbert M. Weaver and Karen W. | 4829 Road 201 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Clear Creek Resource Partners | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| | BNSF Railway Company | 2650 Lou Menk Drive | Fort Worth | TX | 76131-2830 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W<br>Sec. 18: NE | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI / ROW |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | David Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Ann Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Ronald E. Poelma, Trustee under the Ronald E. Poelma Living Trust, u/a dated 06-19-2019 | 8351 Buckboard Road | Cheyenne | WY | 82009 | SI / MI |
| | Joseph J. Poelma and Patricia Poelma c/o Ronald E. Poelma | 8351 Buckboard Road | Cheyenne | WY | 82009 | MI |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| | Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 | MTG |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 1601 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W<br>Sec. 18: E2NW, N2SE | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI / ROW |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | David Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Ann Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Gilbert M. Weaver and Karen W. Weaver | 4829 Road 201 | Carpenter | WY | 82054 | SI |
| | Ronald E. Poelma | 8351 Buckboard Road | Cheyenne | WY | 82009 | MI |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| | Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 | MTG |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 1601 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W<br>Sec. 18: Lots 1, 2, 3, 4, E2SW, S2SE | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI / ROW |
| | Laramie Operating LLC, a Colorado limited liability company | 1120 Lincoln Street, Suite 1605 | Denver | CO | 80203 | WI |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | David Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Ann Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Anita Ruth Johnson c/o Barbara Duggan | P.O. Box 35 | Hereford | CO | 80732 | SI / MI |
| | Francis W. Blake | 5700 East CR 48 | Fort Collins | CO | 80524 | MI |
| | Francis W. Blake, Trustee of the Ettie P. Blake Living Trust, dated 08-15-1988 | 5700 East CR 48 | Fort Collins | CO | 80524 | MI |
| | WYOCO Royalty Partners, LLC, a Colorado limited liability company | 410 17th Street, Suite 1150 | Denver | CO | 80202 | MI |
| | Kathleen Eastman-Lorenz, Successor Trustee of the Michael Philip Lorenz Revocable Living Trust | P.O. Box 1863 | Lihue | HI | 96766 | MI |
| | Mark Jenkins and Karen R. Jenkins | 11776 County Road 42 | Platteville | CO | 80651 | MI |
| | Wolfhawk Energy Holdings, LLC | 999 18th Street, Suite 16508 | Denver | CO | 80202 | MI |
| | McClintock & Nikoloric, LLC, BOKF, NA dba Colorado State Bank and Trust, Agent | P.O. Box 3499 | Tulsa | OK | 74101 | MI |
| | T.E. McClintock T/W fbo Mary M. Swift, U.S. Bank, N.A., Trustee | P.O. Box 17532 | Denver | CO | 80217 | MI |
| | Mildred Elizabeth Hewitt Bunnell | 1901 Howell Avenue | Worland | WY | 82401 | MI |
| | Roger G. Bunnell | 612 Sweetwater Avenue | Alliance | NE | 69301 | MI |
| | Tom Bunnell, aka Tommy Lynn Bunnell | 821 Russell Avenue | Worland | WY | 82401 | MI |
| | Donald W. Bubar | 10408 Creighton Road | SW Fife Lake | MI | 49633 | MI |
| | Ted A. Bunnell, aka Teddy Alan Bunnell | 203 Jim Street | Billings | MT | 59101 | MI |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| | Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 | MTG |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | U S West Communications, Inc. | 1601 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T12N - R63W<br>Sec. 1: Lots 1-4, S2N2 | The Cheryl Ann Jeffers Living Trust u/d/a dated April 19, 2019, Cheryl Ann Jeffers as Trustee | P.O. Box 454 | Carpenter | WY | 82054 | SI / MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | ROW |
| | AT&T Mobility Corporation | 1025 Lenox Park Blvd. NE 3rd Floor | Atlanta | GA | 30319 | ROW |
| | Allen D. and April J. Kinnison | 274 Road 147 | Carpenter | WY | 82054 | SI / MI |
| | Kaiser-Francis Oil Company | P.O. Box 21468 | Tulsa | OK | 74121 | WI |
| | CBK Investments, LLC | P.O. Box 21468 | Tulsa | OK | 74121 | WI |
| | Verdad Resources, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 | WI |
| | CBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ORRI |
| | Wyoming Bank & Trust | 5827 Yellowstone Road | Cheyenne | WY | 82009 | MTG |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | T10 Unison Site Management LLC | P.O. Box 1951 | Frederick | MD | 21702 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T12N - R63W<br>Sec. 1: SW | Mariland N. Gourley | 1400 North Rocking Horse Lane | Benson | AZ | 85602 | SI |
| | Anadarko Land Corp., a Nebraska corporation, formerly Union Pacific Land Resources Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| T12N - R63W<br>Sec. 1: SE | The Cheryl Ann Jeffers Living Trust u/d/a dated April 19, 2019, Cheryl Ann Jeffers as Trustee | P.O. Box 454 | Carpenter | WY | 82054 | SI / MI |
| | Emmanuel Farm LLP | 220 Road 148 | Carpenter | WY | 82054 | SI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| T12N - R63W<br>Sec. 2: Lots 1, 2, 3, 4 , S2N2, SW | Grace Valley, LLC | P.O. Box 391 | Carpenter | WY | 82054 | SI |
| | Allen D. and April J. Kinnison | 274 Road 147 | Carpenter | WY | 82054 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Lester D. True, Trustee, or his successors in trust, under the Lester D. True Living Trust dated 1/17/2003 | 274 Road 147 | Carpenter | WY | 82054 | MI |
| | Covault Resources, LLC | 101 Cook St, Suite 3000 | Denver | CO | 80206 | MI |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| T12N - R63W<br>Sec. 2: SE | Michael D. Konig and Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 | MI |
| | Mark R. Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | David F. Stagg | 9609 239th Street North | Port Byron | IL | 61275 | MI |
| | LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 | MTG |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| T12N - R63W<br>Sec 3: Lots 1-4, S2N2, S2 | Grace Valley, LLC | P.O. Box 391 | Carpenter | WY | 82054 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Rearden Minerals, LLC | 5914 W. Courtyard Drive | Austin | TX | 78730 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Bill Barkley | 10115 Branding Iron Drive | Cheyenne | WY | 82009 | MI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Farmers Bank | P.O. Box 220 | Ault | CO | 80610 | MTG |
| T12N - R63W<br>Sec. 4: Lots 1-4, S2N2, S2 | Sidwell Ranch, LLC | 392 County Road 145 | Carpenter | WY | 82054 | SI / ROW |
| | Gordon Malm Revocable Trust | P.O. Box 55 | Albin | WY | 82050 | SI / MI |
| | Jerald F. Sidwell | 4481 Road 203 | Carpenter | WY | 82054 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Walter L. Farrington, III | P.O. Box 640766 | Dallas | TX | 75367 | MI |
| | Red Harlan Royalties, LTD. | P.O. Box 670766 | Dallas | TX | 75367 | MI |
| | Audie Hoke and Cherie R. Hoke | 2509 Crosstimbers Drive | College Station | TX | 77840 | MI |
| | Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 | MI |
| | MAP2009-OK c/o MAP Royalty, Inc. | 101 North Robinson Avenue, Suite 1000 | Oklahoma City | OK | 73102 | MI |
| | Albert H. Glassburn and Mary E. Glassburn, husband and wife | P.O. Box 755 | Jackson | WY | 83001 | MI |
| | Fossil Creek Land Company | P.O. Box 485 | Mustang | OK | 73064 | MI |
| | Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 | MI |
| | Charles W. and Patty N. Brown, LLC | 6408 Outabounds Court | Oklahoma City | OK | 73116 | MI |
| | The Bluffs, LLC | 392 County Road 145 | Carpenter | WY | 82054 | MI |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | The Ridge, LLC | 392 County Road 145 | Carpenter | WY | 82054 | MI |
| | Bold Resources, LLC | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Deborah L. Shepardson | 811 Heather Lane | Montrose | CO | 81401 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Kaiser-Francis Mid-Continent Limited Partnership | P.O. Box 2280 | Tulsa | OK | 74101 | WI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 | WI |
| | Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 | WI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Enerquest Oil & Gas, L.L.C. | 12368 Market Drive | Oklahoma City | OK | 73114 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | WI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Simmons Bank | 3001 Brighton Boulevard, Suite 718 | Denver | CO | 80216 | MTG |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Farmers & Merchants Bank of Colby | P.O. Box 797 | Colby | KS | 67701 | MTG |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| T12N - R63W<br>Sec. 5: Lots 1-4. S2N2, S2 | The Gordon Malm Revocable Trust dated 02-20-1998 | P.O. Box 55 | Albin | WY | 82050 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | Lost River Trading Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Red Harlan Royalties, LTD. | P.O. Box 670766 | Dallas | TX | 75367 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | U.S. Bank, National Association | Attention Global Corporation<br>950 17th Street | Denver | CO | 80202 | MTG |
| | U.S. Bank, National Association | Corporate Trust Services<br>60 Livingston Ave<br>EP-MN-WS3C | St. Paul | MN | 55107 | MTG |
| | U.S. Bank, National Association | Corporate Trust Services<br>40 Pearl Street NW, Suite 838 | Grand Rapids | MI | 49503 | MTG |
| | U.S. Bank Trust Company, N.A. | 425 Walnut Street, 6th Floor | Cincinnati | OH | 45202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | Basin Electric Power Cooperative | 1717 E. Interstate Avenue | Bismarck | ND | 58503 | ROW |
| | Western Minnesota Power Agency | 220 South 6th St., Suite 1300 | Minneapolis | MN | 55402 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| T12N - R63W<br>Sec. 6: Lots 1-5, SENW, S2NE | Fred L. Acheson and Diana K. Joint Revocable Trust | P.O. Box 220 | Hillsdale | WY | 82060 | SI / MI |
| | Cox Minerals LLC | 2812 1st Avenue North | Billings | MT | 59103 | MI |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | ORRI |
| | Sherry Cox Dupee | 105 Fair Acres Road | Oxford | England | OX4 - 1 TQ | MI |
| | ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 | MI |
| | Janice Ann Taylor aka Jan Taylor aka Janice A. Taylor | 636 E. Magnesium Rd. Apt C-111 | Spokane | WA | 99208 | MI |
| | LOR Capital I, LLC | 1120 Lincoln Street, Suite 1605 | Denver | CO | 80203 | WI |
| | Faith Partners Land Company, LLC | 4772 Tara Ct. | West Bloomfield | MI | 48323 | ORRI |
| | WYDJ ORI Investments I, LLC | P.O. Box 460868 | Denver | CO | 80246 | ORRI |
| | WYDJ Energy LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | WYDJ Investments I LLC | 1120 Lincoln St. Suite 908 | Denver | CO | 80203 | ORRI |
| | WOV, LLC | 1120 Lincoln St. Suite 908 | Denver | CO | 80203 | WI |
| | Kimberly T. Dunn | 2631 W. Dell Drive | Spokane | WA | 99208 | MI |
| | Ross M. Taylor | 34752 Bachelor Flat Road | St. Helens | OR | 97051 | MI |
| | Norman Harada | Unknown Address | | | | WI |
| | Kestrel Properties Corp. | P.O. Box 3972 | Morrison | CO | 80465 | ORRI |
| | Alice G. Tower | 2434 Rancho Road | Billings | MT | 59102 | MI |
| | E. Lee Tower | Box 1770 | Redlodge | MT | 59068 | MI |
| | Jill Jahn, aka Jill Tower aka Jill F. Tower | P.O. Box 156 | Fishtail | MT | 59222 | MI |
| | Keith Tower and Martha J. Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 | MI |
| T12N - R63W<br>Sec. 6: Lots 6, 7, E2SW, SE | Patrick M. Goodwine | 240 Road 143 | Carpenter | WY | 82054 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI / ROW |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | ROW |
| | Jimmie Dee Talkington | Box 224 | Hillsdale | WY | 82060 | MI |
| | Lela Sue Dennis | Box 6 | Lingle | WY | 82223 | MI |
| | Connie Faye Snyder | 8203 A Wyncote Rd | Lingle | WY | 82223 | MI |
| | Joann Soto | 3338 Vanvelzor #B | Cheyenne | WY | 82001 | MI |
| | Roger West Stanton, heir of Marcus A.W. Stanton, heir of Janet L. Stanton, Heir of Harlett Isabel Stanton | P.O. Box 3972 | Chico | CA | 95927 | MI |
| | Janet I. Stanton, a widow | 3086 Stadium Ave | Napa | CA | 94558 | MI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| | Simmons Bank | 3001 Brighton Boulevard, Suite 718 | Denver | CO | 80216 | MTG |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | WI |
| | Stephen Gifford Stanton, aka Stephen G. Stanton | 56 Napa Valley Club Circle | Napa | CA | 94558 | MI |
| | Mark Worthington, Marcus Stanton Worthington aka Mark S. Worthington aka Marcus Stanton Walterstein | 1622 Ora Drive | Napa | CA | 94559 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | James S. Worthington aka James Stanton Worthington aka Jim S. Worthington aka James Stanton Walterstein | 559 7th St. W | Sonoma | CA | 95476 | MI |
| | Frank Worthington aka Frank Walterstein, heir of Harriett Stanton Walterstein aka Harriett Stanton Worthington aka Harriett Stanton Gilleas, heir of Harlett Isabel Stanton | 1200 Mira Mar Ave. #931 | Medford | OR | 97504 | MI |
| T12N - R63W<br>Sec. 7: All | Phillip V. Breeden Revocable Trust Dated December 13, 2013 | 90 County Road 143 | Carpenter | WY | 82054 | SI / MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | MTG |
| | Clear Creek Fund I-B, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | MTG |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | WI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | MI |
| | Clear Creek Fund I-A, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Double Eagle Energy Rockies, LLC | 1401 Ballinger Street, Suite 203 | Fort Worth | TX | 76102 | WI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI / WI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Noble Energy, Inc. | 1625 Broadway, Suite 2200 | Denver | CO | 80202 | MTG |
| | Cirque Brennsee, LLC | 475 17th Street, Suite 1600 | Denver | CO | 80202 | WI |
| | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 | WI |
| | Jeanie M. Grogan | 613 SW Drive | Cheyenne | WY | 82007 | MI |
| | Katherine Tippy Castello aka K. Tippy Costello | 1209 W. 22nd Street | Cheyenne | WY | 82001 | MI |
| | James E. and Kina M. Costello Family Trust dated December 23, 1999 | 613 SW Drive | Cheyenne | WY | 82007 | MI |
| | Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| T12N - R63W<br>Sec. 8: All | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ORRI |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | Ardith A. Cushing Revocable Trust dated October 17, 2023 | 1105 Beech Avenue | Pine Bluffs | WY | 82082 | ORRI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | Moondance Minerals LP | P.O. Box 8445 | Denver | CO | 80201 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | MTG |
| | Clear Creek Fund I-B, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | MTG |
| | U.S. Bank Trust Company, N.A. | 425 Walnut Street, 6th Floor | Cincinnati | OH | 45202 | MTG |
| | U.S. Bank Trust Company, N.A. | 425 Walnut Street, 6th Floor | Cincinnati | OH | 45202 | MTG |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | WI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | MI |
| | Clear Creek Fund I-A, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Double Eagle Energy Rockies, LLC | 1401 Ballinger Street, Suite 203 | Fort Worth | TX | 76102 | WI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI / WI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Noble Energy, Inc. | 1625 Broadway, Suite 2200 | Denver | CO | 80202 | MTG |
| | Cirque Brennsee, LLC | 475 17th Street, Suite 1600 | Denver | CO | 80202 | WI |
| | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 | WI |
| | Jeanie M. Grogan | 613 SW Drive | Cheyenne | WY | 82007 | MI |
| | Katherine Tippy Castello aka K. Tippy Costello | 1209 W. 22nd Street | Cheyenne | WY | 82001 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | James E. and Kina M. Costello Family Trust dated December 23, 1999 | 613 SW Drive | Cheyenne | WY | 82007 | MI |
| | Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| T12N - R63W<br>Sec. 9: All | Kyle W. Breeden and Katherine Tippy Costello, hw as t/b/e | 149 County Road 143 | Carpenter | WY | 82054 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | LPR Investments South LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | MI |
| | Ardith A. Cushing Revocable Trust dated October 17, 2023 | 1105 Beech Avenue | Pine Bluffs | WY | 82082 | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | WI |
| | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 | WI |
| | Noble Energy, Inc. | 1625 Broadway, Suite 2200 | Denver | CO | 80202 | WI |
| | Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | ROW |
| | Riverstone Credit Management Cortland Capital Market Services, LLC | 225 West Washington Street<br>21st Floor | Chicago | IL | 60606 | MTG |
| T12N - R63W<br>Sec. 10: All | Grace Valley, LLC | P.O. Box 391 | Carpenter | WY | 82054 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | Rearden Minerals, LLC | 5914 W. Courtyard Drive | Austin | TX | 78730 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Bill Barkley | 10115 Branding Iron Drive | Cheyenne | WY | 82009 | MI |
| | Gerald R. and Carl E. Zimmerman, co-trustees of the Laura E. Zimmerman Family Trust, created 5/29/2006 | Unknown Address | | | | MI |
| | John Dean | P.O. Box 1028 | Gilmer | TX | 75644 | MI |
| | Hydrocarbon Holdings, LTD | P.O. Box 1135 | Bridgeview | IL | 604555 | MI |
| | Craig L. Emmanuel | P.O. Box 86 | Laramie | WY | 82073 | MI |
| | Karhu Resources LLC | P.O. Box 272229 | Fort Collins | CO | 80527 | MI |
| | Keith Michael Foster and Lisa Marie Foster, JTwROS | 13824 West Amherst Way | Lakewood | CO | 80228 | MI |
| | Brian M. Foster | 13824 West Amherst Way | Lakewood | CO | 80228 | MI |
| | Catherine M. Enzo | 12230 Cherry Street | Thornton | CO | 80241 | MI |
| | Rory G. Owens | 220 Chapel Hill Drive | Prosper | TX | 75078 | MI |
| | Blaise E. McEwan | 5825 Bay Point Drive | Lake Oswego | OR | 97032 | MI |
| | Courtney R. Jones | 10810 Yeomans Park Drive | Colorado Springs | CO | 80908 | MI |
| | O S Property Development | 881 Ocean Drive, Casa De; Mar, Apartment 6G | Key Biscayne | FL | 33149 | MI |
| | Patricia Pico | 14438 Kingston Cove Lane | Houston | TX | 77077 | MI |
| | J15, LLC | P.O. Box 31749 | Palm Beach Gardens | FL | 33420 | MI |
| | Robert P. Dykes, as Trustee of The Robert P. Dykes Revocable Trust, dated 10/14/2011 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | J. Christopher Dykes, as Trustee of The J. Christopher Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Michael L. Dykes, as Trustee of The Michael L. Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Sharon McDonald | 107 Roger's Lane, CR 302 | Durango | CO | 81303 | MI |
| | Terry Lee Faber | 2901 Hermosa Court | Grand Junction | CO | 81504 | MI |
| | Natalie Shea Faber-Padmos | 263 River Vlley Road, #06-17 | Singapore | | 238309 | MI |
| | Neal Brent Faber | 3504 A Cannon Street | Twentynine Palms | CA | 29910 | MI |
| | McCulliss Oil & Gas, Inc. | P.O. Box 221515 | Denver | CO | 80222 | MI |
| | McCulliss Resources Co., Inc. | P.O. Box 3248 | Littleton | CO | 80161 | MI |
| | George G. Vaught, Jr. | P.O. Box 13557 | Denver | CO | 80201 | MI |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Farmers Bank | P.O. Box 220 | Ault | CO | 80610 | MTG |
| | Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 | NPRI |
| | Mark Strader | 14932 Turn Bridge Drive | Frisco | TX | 75035 | NPRI |
| | Joshus D. Vance and Brandy E. Vance, JT | 108 Woodland Drive | Krugerville | TX | 76227 | NPRI |
| | Victoria A. Ladd | 608 Wentworth Drive | McKinney | TX | 75070 | NPRI |
| | James S. Witherell Trust Dated 6/17/1997, James S. Witherell, Trustee | 2610 Deep Cut Road | Woodstock | IL | 60098 | NPRI |
| | William E. Hill and Jan C. Hill, husband and wife | 91 Wood Road | Centereach | NY | 11720 | NPRI |
| | ELSR LP, A Texas Limited Partnership, Bengal Jones Group LLC, General Partner | 8080 North Central Expressway, Suite 1420 | Dallas | TX | 75206 | NPRI |
| | Mariemont Properties, Inc | 3429 Southwestern Boulevard | Dallas | TX | 75225 | NPRI |
| | Karl Schreiber | 5100 Miller Road | Brecksville | OH | 44141 | NPRI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Bambi Fernandez 2004 Trust | 1637 Edmonton Avenue | Sunnyvale | CA | 94087 | NPRI |
| | Thomas E. Shows and Edna M. Shows, JT | 150 Tom Shows Road | Seminary | MS | 39479 | NPRI |
| | Charles Fuller 2006 Trust, Charles F. Fuller, Trustee | 722 Jacaranda Circle | Hillsborough | CA | 94010 | NPRI |
| | Zachary Gleit, Trustee of the Roberta Gleit Revocable Trust dated February 24, 2018 | 4301 North Ocean Boulevard | Boca Raton | FL | 33431 | NPRI |
| | Thomas J. Buckley | 2310 Royal Oaks Drive | Mansfield | TX | 76063 | NPRI |
| | Mitsuo Fuse | 14901 Quorum Drive, # 800 | Dallas | TX | 75254 | NPRI |
| | Tommarr, LLC | 108 Nickerson Lane | Romeo | ME | 04963 | NPRI |
| | Thomas A. Alico | 410 Waterside Lane | Nokomis | FL | 34275 | NPRI |
| | Ken Ward and Janet Ward, JT | 732 Bluff Ridge Drive | Cedar Hill | TX | 75104 | NPRI |
| | Gerald E. Werner | 10254 South 700 West | Union Mills | IN | 46382 | NPRI |
| | Barry A. Craft | 6416 Aston Park Drive | Oak Ridge | NC | 27310 | NPRI |
| | Edward N. Strader and Carol N. Strader, JTwROS | 3718 Dover Road | Cheyenne | WY | 82001 | NPRI |
| | Ralf R. Filler and Loretta D. Filler, JT | 4715 Langford Lane | Wichita Falls | TX | 76310 | NPRI |
| | John R. Sellers | 4019 West 176th Street | Torrance | CA | 90504 | NPRI |
| | Dimple Dene Hummer | 5901 Forest Ledge | San Antonio | TX | 78240 | NPRI |
| | David A. Dent | 6712 Arrowhead Pass | Edina | MN | 55439 | NPRI |
| | Brian Summer | 46 Conway Street, Suite B | Shellburne Falls | MA | 01370 | NPRI |
| | Wake Family Living Trust Dated 1/5/1994, Harold E. Wake, Trustee | 1013 Oakwook Circle | Carmel | CA | 93923 | NPRI |
| | The Jacobson Family Trust UA Dated 1/5/1994, Elaine Virginia Jacobson, Trustee | 1864 Lime Tree Lane | Mountain View | CA | 94040 | NPRI |
| | Albert Goodis and Barbara Buck, Individually | 111 Water Rock Circle | Wayneville | NC | 28786 | NPRI |
| | Jack E. Earnest | 5945 Shady Circle Drive | Houston | TX | 77057 | NPRI |
| | Warren Lawrence and Nanch Kay Lawrence, JT | 2535 South Newton Street | Denver | CO | 80219 | NPRI |
| | David W. Galehouse and Deborah K. Hartman, JT | 3216 Deweese Parkway | Dayton | OH | 45414 | NPRI |
| | John Spicer | 5956 Bannock Hwy | Pocatello | ID | 83204 | NPRI |
| | Ted N. Steffen Trust (or his successor) of a Trust created on 2/3/2003 | 2404 Barret Hill Road | Louisville | KY | 40205 | NPRI |
| | Grant W. Avery Declaration of Trust dated 6/20/2008 | 15543 Southeast Frontage Road | Plainfield | IL | 60544 | NPRI |
| | Michael E. Cherry | 49273 295th | Genoa | NE | 68640 | NPRI |
| | Andrew L. Peabody | P.O. Box 2120 | Natchez | MS | 39121 | NPRI |
| | Rodella Vergamini and John Vergamini, TIC | 146 Vine Street | Council Bluffs | IA | 51503 | NPRI |
| | George A. Longo | 505 North West CR 0011 | Corsicana | TX | 75110 | NPRI |
| | Dale Harlan | 7005 Wagon Train Road | Hickman | NE | 68372 | NPRI |
| | Robert E. Dettle and Rosalie T. Dettle Living Trust Dated 2/29/1980, Robert E. Dettle, Trustee | 1101 Water Street | Santa Cruz | CA | 95062 | NPRI |
| | Richard B. Juenemann Revocable Trust Dated 7/18/2007, Richard B. Junemann, Trustee | 32768 220th Street | Sanborn | MN | 56083 | NPRI |
| | Vincent Kunderman | 17319 Hilltop Ridge Drive | Eureka | MO | 63025 | NPRI |
| | Jim Mamot | 233 Friend Road | St. Liberty | NE | 68872 | NPRI |
| | Jim Clayton | 1258 Whispering Oaks | Desoto | TX | 75115 | NPRI |
| | Derk Smith | 3321 Heritage Lake Drive | Lockport | IL | 60441 | NPRI |
| | John C. Peterson and Bernadette J. Peterson, JT | 12472 89th Place | Maple Grove | MN | 55369 | NPRI |
| | Preston Real Estate, LLC | 11904 Arbor Street, Suite 200 | Omaha | NE | 68114 | NPRI |
| | Maryl Betzwiser | 6369 Whitetail Ridge Court | Yorkville | IL | 60560 | NPRI |
| | Brian H. Davis | 628 Aqua Circle | Lino Lakes | MN | 55014 | NPRI |
| | Judith L. Avery | 23524 West Copper Drive | Plainfield | IL | 60544 | NPRI |
| | Karl A. Willey Rev. Trust, Karl A. Willey, Trustee | 412 North Young | Caldwell | KS | 67022 | NPRI |
| | Karl A. Glastad | 8 Sunset Trail | Heath | TX | 75032 | NPRI |
| | Matthew Witherell and Kristin L. Witherell, JT | 4 Oxford Drive | Rogers | AR | 72758 | NPRI |
| | Alton Dwyer | 6921 South West 178th Avenue | Southwest Ranches | FL | 33331 | NPRI |
| | Kenneth W. Morris | 2121 Haas Road | Apopka | FL | 32712 | NPRI |
| | C Three J, LLC | 13705 Highway 11 | Allendale | IL | 62410 | NPRI |
| | Bernard Caputo | 34 Woodcrest Road | Boxford | MA | 01921 | NPRI |
| | RAL Farms LLC, an Indiana Limited Liability Company | 13525 Bunker Hill Lane | St. Francisville | IL | 62460 | NPRI |
| | Harold R. Barr | 4299 South 75 West | Laporte | IN | 46350 | NPRI |
| | Robert l Canvarl Jr. | 6237 Ella Lee Lane | Houston | TX | 77057 | NPRI |
| | Ruby Resources, LLC | 1530 P B Ln # 3592 | Wichita Falls | TX | 76302-2612 | NPRI |
| | Arthur G. Rice | 5228 US Hwy 421 N | Wilmington | NC | 28401 | NPRI |
| | Provident Trust Group, LLC as custodian FBO Dennis J. Kulonda Traditional IRA 180901668 | 8880 Sunset Road, Suite 250 | Las Vegas | NV | 89148 | NPRI |
| | RDMB Holdings, Inc | 3106 Druid Hill Drive | Des Moines | IA | 50315 | NPRI |
| | Thomas E. Werlin | 62 Legend Lane | Houston | TX | 77024 | NPRI |
| | Gerald W. Simonson | 5813 Jeff Place | Edina | MN | 55436 | NPRI |
| | Ivan K. Gilling | 14250 County Road AA | La Jara | CO | 81140 | NPRI |
| | Equity Trust Company Custodian FBO Gary F. Hansen IRA | 225 Burns Road | Elyria | OH | 44035 | NPRI |
| | Gary Larson and Jeanine D. Larson, JT | 715 N. 25th St | Mesa | AZ | 85213 | NPRI |
| | IRA Resources, Inc., FBO: Harry W. Buehrle, II IRA 32486 | 6825 La Jolla Boulevard | La Jolla | CA | 92037 | NPRI |
| | Equity Trust Company Custodian FBO Arthur J. Powell Jr. IRA | P.O. Box 1529 | Elyria | OH | 44035 | NPRI |
| | Leopoldo Rodriguez | 4206 Ridgelane Drive | Colorado Springs | CO | 80918 | NPRI |
| | Equity Trust Company Custodian FBO Matthew V. Lee JR., Roth IRA #43612F77 | 225 Burns Road | Elyria | OH | 44035 | NPRI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Ralph A. Bard, III | 59-425 Makana Road | Haleiwa | HI | 96712 | NPRI |
| | Advanta IRA Trust, LLC FBO: Gale E. Christenson IRA xxx6601 | 1520 Royal Palm Square Boulevard #320 | Fort Myers | FL | 33919 | NPRI |
| | Advanta IRA Trust, LLC FBO: Mark K. Christenson IRA xxx6401 | 1520 Royal Palm Square Boulevard #320 | Fort Myers | FL | 33919 | NPRI |
| | Equity Trust Company Custodian FBO Kent Nygren IRA | 225 Burns Road | Elyria | OH | 44035 | NPRI |
| T12N - R63W | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | SI / MI |
| Sec. 11: NE | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 | MI |
| | Kaiser-Francis Oil Company | P.O. Box 21468 | Tulsa | OK | 74121 | WI |
| | American Shale Energy LLC | 2929 Buffalo Speedway Suite 2106 | Houston | TX | 77098 | WI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ORRI |
| | Mark R. Stagg, life estate with remaindermen being his children Kristine Stagg, Josephine Stagg, Jacqueline Stagg, Jeannette Stagg and Julianne Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | WI |
| | Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 | MTG |
| T12N - R63W | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | SI |
| Sec. 11: NW | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI / WI |
| | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI / ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 | MTG |
| T12N - R63W | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | SI / MI |
| Sec. 11: SW | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | MI |
| | Longs Peak Resources, LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | WI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch 90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R63W | JFK Ag, LLC | 37174 County Road 124 | Grover | CO | 80729 | **SI** |
| Sec. 11: SE | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch 90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | WI |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI / ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R63W | Emmanuel Farm LLP | 220 Road 148 | Carpenter | WY | 82054 | SI |
| Sec. 12: NE | The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | HRM Resources II, LLC | 410 17th Street, Suite 1600 | Denver | CO | 80202 | ORRI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI / ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R63W<br>Sec. 12: NW | The te Velde Family LLLP | 7619 Road 19 | Fort Lupton | CO | 80621 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 | MI |
| | Kaiser-Francis Oil Company | P.O. Box 21468 | Tulsa | OK | 74121 | WI |
| | American Shale Energy LLC | 2929 Buffalo Speedway<br>Suite 2106 | Houston | TX | 77098 | WI |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ORRI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | Mark R. Stagg, life estate with remaindermen being his children Kristine Stagg, Josephine Stagg, Jacqueline Stagg, Jeannette Stagg and Julianne Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 | MI |
| | Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 | MI |
| | Charles W. and Patty N. Brown, LLC | P.O. Box 587 | Marlow | OK | 73055 | MI |
| | Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | MAP2009-OK c/o MAP Royalty, Inc. | 101 North Robinson Avenue, Suite 1000 | Oklahoma City | OK | 73102 | MI |
| | Bold Resources, LLC | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Bluebird Energy Partners, LLC | 9055 E. Mineral Circle, Suite 110 | Centennial | CO | 80112 | MI |
| | Oxford Exploration, LLC | 450 East 17th Avenue<br>Suite 320 | Denver | CO | 80203 | MI |
| | BFG Minerals, LLC | 225 S. Broadway, Suite 9847 | Denver | CO | 80209 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Farmers State Bank | P.O. Box 252 | Chadron | NE | 63337 | MTG |
| | American Agcredit, FLCA | P.O. Box 1120 | Santa Rosa | CA | 95402 | MTG |
| T12N - R63W<br>Sec. 12: SW, N2SE, SWSE | Emmanuel Farm LLP | 220 Road 148 | Carpenter | WY | 82054 | SI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1600 | Denver | CO | 80202 | ORRI |
| | LPR Investments South LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | ORRI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Texas American Resources Co. | 410 17th Street, Suite 1610 | Denver | CO | 80202 | ROW |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI / ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| | Wells Fargo Bank , N.A. | 1700 Lincoln Street<br>Third Floor MAC C7300-003 | Denver | CO | 80203 | MTG |
| T12N - R63W<br>Sec. 12: SESE | Anita Ruth Johnson<br>c/o Barbara Duggan | P.O. Box 35 | Hereford | CO | 80732 | SI / MI |
| | Mark Jenkins | 20030 WCR 33 | LaSalle | CO | 50645 | MI |
| | Karen R. Jenkins | 20030 WCR 33 | LaSalle | CO | 50645 | MI |
| | Kathaleen Ann Eastman-Lorenz | P.O. Box 1863 | Lihue | HI | 96766 | MI |
| | Morgan Jane Eastman-Lorenz | P.O. Box 1863 | Lihue | HI | 96766 | MI |
| | Camden Carol Lorenz | P.O. Box 1863 | Lihue | HI | 96766 | MI |
| | Wolfhawk Energy Holdings, LLC | 999 18th Street, Suite 1605S | Denver | CO | 80202 | MI |
| | Francis W. Blake | 5700 East CR 48 | Fort Collins | CO | 80524 | MI |
| | Francis W. Blake, Trustee of the Ettie P. Blake Living Trust, dated 08-15-1988 | 5700 East CR 48 | Fort Collins | CO | 80524 | MI |
| | McClintock & Nikoloric, LLC, BOKF, NA dba Colorado State Bank and Trust, Agent | P.O. Box 3499 | Tulsa | OK | 74101 | MI |
| | Bank of Oklahoma, N.A., as Agent for U.S. Bank, N.A., Trustee of the T.E. McClintock T/U/W fbo Mary M. Swift | P.O. Box 3499 | Tulsa | OK | 74101 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1600 | Denver | CO | 80202 | ORRI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | ORRI |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R63W<br>Sec. 13: All | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Todd Alan Martin and Sydnee Marie Martin as Co-Trustees of the Todd Alan Martin and Sydnee Marie Martin Marital Trust u/t/a dated 11-21-2019 | 169 County Road 148 | Carpenter | WY | 82054 | SI |
| | Arnold and Jeanne Bautista | 94 Road 148 | Carpenter | WY | 82054 | SI |
| | Anita Ruth Johnson<br>c/o Barbara Duggan | P.O. Box 35 | Hereford | CO | 80732 | SI / MI |
| | United States of America / | 5353 Yellowstone Road | Cheyenne | WY | 82009 | MI |
| | Mountain States Telephone and Telegraph Company | Unknown Address | | | | ROW |
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | ROW |
| | State of Wyoming<br>Office of State Lands & Investments | Herschler Building<br>122 W. 25th Street - W103 | Cheyenne | WY | 82002 | MTG |
| | Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 | MTG |
| | Meridian Trust Federal Credit Union | P.O. Box 548 | Cheyenne | WY | 82003 | MTG |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Ware Family, LLC c/o Yvonne L. Ware | P.O. Box 423 | Carpenter | WY | 82054 | MI |
| | L P R Investment South, LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | MI |
| | June Cushing | Unknown Address | | | | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis and Ardith A. Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Russell Mosier c/o Mark and Karen Jenkins | 11776 County Road 42 | Platteville | CO | 80651 | MI |
| | Wolfhawk Energy Holdings, LLC | 999 18th Street, Suite 16508 | Denver | CO | 80202 | MI |
| | Kathleen Eastman-Lorenz, Successor Trustee of the Michael Philip Lorenz Revocable Living Trust | P.O. Box 1863 | Lihue | HI | 96766 | MI |
| | U.S. National Bank NA, Trustee of the T. E. McClintock Mineral Trust c/o US Bank | P.O. Box 17532 | Denver | CO | 80217 | MI |
| | Francis W. Blake, Trustee of the Ettie P. Blake Living Trust, dated 08-15-1988 | 5700 East CR 48 | Fort Collins | CO | 80524 | MI |
| | Francis W. and E. Joanne Blake | P.O. Box 79 | Hereford | CO | 80732 | MI |
| | The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083 | MI |
| | Mark and Karen R. Jenkins | 20030 WCR 33 | LaSalle | CO | 80645 | MI |
| | Phillip and Rudy Breeden | Unknown Address | | | | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| T12N - R63W<br>Sec. 14: All | Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 | MTG |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | ROW |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ROW |
| | Richard Breeden | Unknown Address | | | | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Gary Breeden | Unknown Address | | | | MI |
| | Susie Breeden | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | MI |
| | Thomas V. Breeden | 565 S. Parfet | Lakewood | CO | 80226 | MI |
| | June Cushing | Unknown Address | | | | MI |
| | John Francis and Ardith A. Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | Harvey Miller | Unknown Address | | | | MI |
| | John H. Hueske | Unknown Address | | | | MI |
| | Francis Cushing | Unknown Address | | | | MI |
| | The Federal Land Bank of Omaha | 206 S. 19th St. | Omaha | NE | 68102 | MI |
| | Harold F. Baumgartner | Unknown Address | | | | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | SI / MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | SI / MI |
| | Sandra A. Meyers | Unknown Address | | | | MI |
| | Abby Jo Ragan | Unknown Address | | | | MI |
| T12N - R63W | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | SI / MI |
| Sec. 15: NE | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Burnett Land & Livestock, Ltd. | 5453 County Road 202 | Carpenter | WY | 82054 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Susan K. Breeden | 2702 19th Street Drive, #17 | Greeley | CO | 80634 | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | William J. Breeden | 3630 Foxcroft Road | Cheyenne | WY | 82001 | MI |
| | Thomas V. Breeden | 565 S. Parfet | Lakewood | CO | 80226 | MI |
| | Karen Anne Breeder | 631 Ash Street | Windsor | CO | 80550 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 | MTG |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R63W | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | SI / MI |
| Sec. 15: NW | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Burnett Land & Livestock, Ltd. | 5453 County Road 202 | Carpenter | WY | 82054 | MI |
| | Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 | MTG |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R63W | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | SI / MI |
| Sec. 15: SW | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R63W | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | SI / MI |
| Sec. 15: SE | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Susan K. Breeden | 2702 19th Street Drive, #17 | Greeley | CO | 80634 | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | MI |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - 63W | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 | WI |
| Sec. 16: All | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | WI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | WI |
| | Halliburton Energy Services, Inc. | 3000 N. Sam Houston Parkway East | Houston | TX | 77032 | WI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | ORRI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | ORRI |
| | Phillip V. Breeden Revocable Trust Dated December 13, 2013 | 90 County Road 143 | Carpenter | WY | 82054 | SI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Phil Kiner and Marsha Kiner, husband and wife | 8225 Arrow Wood Lane | Cheyenne | WY | 82009 | MI |
| | Nancy L. Flynn, Trustee of the Nancy L. Flynn Revocable Trust under agreement dated April 2, 2009, as amended and restated | P.O. Box 289 | Cheyenne | WY | 82009 | MI |
| | Tippy C. Costello | 1209 W. 22nd Street | Cheyenne | WY | 82001 | MI |
| | Jeanie M. Grogan | 613 Southwest Drive | Cheyenne | WY | 82007 | MI |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | Basin Electric Power Cooperative | 1717 E. Interstate Avenue | Bismarck | ND | 58503 | ROW |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ROW |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R63W<br>Sec. 17: All | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 | WI |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Prism Energy, LLC | 4585 S. Taft Way | Morrison | CO | 80465 | WI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | WI |
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | ORRI |
| | Prism Energy, LLC | 4585 S. Taft Way | Morrison | CO | 80465 | ORRI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ORRI |
| | Phillip V. Breeden Revocable Trust Dated December 13, 2013 | 90 County Road 143 | Carpenter | WY | 82054 | SI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Phil Kiner and Marsha Kiner, husband and wife | 8225 Arrow Wood Lane | Cheyenne | WY | 82009 | MI |
| | Nancy L. Flynn, Trustee of the Nancy L. Flynn Revocable Trust under agreement dated April 2, 2009, as amended and restated | P.O. Box 289 | Cheyenne | WY | 82009 | MI |
| | Tippy C. Costello | 1209 W. 22nd Street | Cheyenne | WY | 82001 | MI |
| | Jeanie M. Grogan | 613 Southwest Drive | Cheyenne | WY | 82007 | MI |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Mark T. Cox, III and Elizabeth J. Cox, husband and wife | P.O. Box 47 | Cheyenne | WY | 82009 | ROW |
| | Basin Electric Power Cooperative | 1717 E. Interstate Avenue | Bismarck | ND | 58503 | ROW |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ROW |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R63W<br>Sec. 21: N2 | Phillip V. Breeden Revocable Trust Dated December 13, 2013 | 90 County Road 143 | Carpenter | WY | 82054 | SI |
| | Philip V. Breeden | Box 3 Ranch | Carpenter | WY | 82054 | MI |
| | Tri-State Generation & Transmission Association, Inc. | 12076 Grant Street | Thornton | CO | 80241 | ROW |
| | Wyoming Western Oil | P.O. Box 458 | Pine Bluffs | WY | 82082 | ROW |
| | Zarephath LLC | 4520 14th Street Drive | Greeley | CO | 80524 | ROW |
| | Fifth Creek Energy Operating | 5251 DTC Parkway, Suite 420 | Greenwood Village | CO | 80111 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | WI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| T12N - R63W<br>Sec. 22: All | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | WI / MI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI / ROW |
| | Occidental Petroleum Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Overland Energy Partners I, LLC | 518 17th Street, #1005 | Denver | CO | 80202 | MI |
| | Fifth Creek Energy Operating Company, LLC | 5251 DTC Parkway, Suite 420 | Greenwood Village | CO | 80111 | WI |
| | OG Resources, Inc. | Unknown Address | | | | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Incline Niobrar Parnters, L.P. | 5019 N. Central Expressway, Suite B | Dallas | TX | 75205 | WI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | Michael D. Konig and Tena M. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | SI / MI |
| | Gary D. Rohrbouck | 2170 Pacific Road | Gering | NE | 69341 | SI / MI |
| | Scott D. Rohrbouck | 571 Hourglass Court | Loveland | CO | 80537 | SI / MI |
| | Tammy J. Tenley | 336 Silas Court | Spring Hill | FL | 34609 | SI / MI |
| | Wyoming Western Oil | P.O. Box 458 | Pine Bluffs | WY | 82082 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Superior Oilfield Services Co., LTD | P.O. Box 336356 | Greeley | CO | 80633 | ROW |
| | Exterra Resources, LLC | 256 Seaboard Lane, H101 | Franklin | TN | 37067 | WI |
| | International Lutheran Laymen's League | 660 Mason Ridge Center Dr. | St. Louis | MO | 63141 | MI |
| | Apollo Operating, LLC | 1538 Wazee Street, Suite 200 | Denver | CO | 80202 | WI |
| | DJ Resources Holdings, LLC | One Riverway, Suite 1870 | Houston | TX | 77056 | ORRI |
| | Old West Tours | 601 16th St., Suite C-153 | Golden | CO | 80401 | ORRI |
| | NG Resources, LLC | 9896 Clairton Way | Highlands Ranch | CO | 80126 | ORRI |
| | Stafford Investments, LTD. | P.O. Box 11115 | Midland | TX | 79702-1115 | MI |
| | JLW Investment, LLC | 351 Glencoe Street | Denver | CO | 80220 | ORRI |
| | JH Petroleum, LLC | P.O. Box 621128 | Littleton | CO | 80162-1128 | ORRI |
| | SSALJD Investment Group LLC | P.O. Box 280969 | Lakewood | CO | 80228-0969 | ORRI |
| | Louis A. Oswald, III, Trustee fo the Oswald Family Trust, dated April 27, 1998 | P.O. Box 280969 | Lakewood | CO | 80228-0969 | ORRI |
| | Kelly V. Oswald | 5638 Sanford Road | Houston | TX | 77096 | ORRI |
| | Brent A. Oswald | 1304 Yorkshire Drive | Austin | TX | 78723 | ORRI |
| | Elsie Bettge | 1217 Spruce Dr. | Knoxville | TN | 37920 | ORRI |
| | Albert E. Kranz and Michelle L. Kranz | 406 E. 3rd | Pine Bluffs | WY | 82082 | ORRI |
| | Esther M. Lewis and Duwayne Lewis | 10905 Empire Dr. | Cheyenne | WY | 82009 | MI |
| | Paul C. Mclaury | 300 E. Prosser Rd., Space 17 | Cheyenne | WY | 82007 | ORRI |
| | Shirley Price | 3064 Grier Blvd. | Cheyenne | WY | 82001 | MI |
| | Edward A. Kranz and Julie C. Kranz | 484 County Road 151 | Carpenter | WY | 82054 | ORRI |
| | Kaiser-Francis Oil Company | P.O. Box 21468 | Tulsa | OK | 74121-1468 | WI |
| | Don A. Kranz, Trustee of the Don A. Kranz Revocable Trust, dated April 27, 2016 | 493 County Road 154 | Carpenter | WY | 82054 | MI |
| | Lynne M. Kranz, Trustee of the Lynne M. Kranz Revocable Trust, dated April 27, 2016 | 493 County Road 154 | Carpenter | WY | 82054 | MI |
| | The Lutheran Home | 530 South 26th Street | Omaha | NE | 68105 | MI |
| | Ivan Lee Kranz | 861 County Road 150 | Carpenter | WY | 82064 | MI |
| | Shirley Helen Rose | 3064 Grier Blvd. | Cheyenne | WY | 82001 | WI |
| | Barbara A. Ittig | 44265 Compeigne Drive | Hemet | CA | 92544 | MI |
| | Leona Buhlmann | 42473 Drive 743 | Elwood | NE | 68937 | MI |
| | Jane E. Pihl | 15648 SW Highway 126 | Powell Butte | OR | 97753 | MI |
| | The Oswald Family Irrevocable Trust | 7200 S. Alton Way, Suite B-250 | Centennial | CO | 80112 | ORRI |
| | Calf Creek Royalty, Ltd. | P.O.Box 3240 | Midland | TX | 79702 | MI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121-1468 | WI |
| | Stephen Deaver aka The Reverend Stephen Deaver | 615 W. 42nd Street | Scottsbluff | NO | 69361 | MI |
| | Sisters of St. Francis | 5314 N. Columbine Road | Denver | CO | 80221 | ORRI |
| | Sandra Ann Anthony | 6401 Ohio Drive, Apt. 1104 | Plano | TX | 75024 | ORRI |
| | Father Richard Rohr aka The Reverend Richard Rohr, O.F.M. | P.O. Box 12464 | Albuquerque | NM | 87195 | MI |
| | Food for the Poor, Inc. | 6401 Lyons Road | Coconut Creek | FL | 33073 | MI |
| | Jeff Tracy | 1416 8th Avenue | Scottsbluff | NE | 69361 | MI |
| | Top Notch Land Services, Inc. | P.O. Box 328 | Kimball | NE | 69145 | WI |
| | CNOOC Energy U.S.A. LLC | 945 Bunker Hill Road, Suite 1000 | Houston | TX | 77024 | MI |
| | Verdad Resources, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 | WI |
| | Catholic Relief Services | 228 W. Lexington St. | Baltimore | MD | 21201-3443 | MI |
| | Center of Action and Contemplation | P.O. Box 12464 | Albuquerque | NM | 87195 | MI |
| | JP Morgan Chase Bank, N.A. | 1125 17th St., Floor 2 | Denver | CO | 80202 | MTG |
| | Del Rio Royalty Company, LLC | 3400 S. Broadway, Suite 100 | Englewood | CO | 80113 | MI |
| | Anthony LLC | 21 Dowd Court | Kimball | NE | 69145 | MI |
| | WK Land Company | 911 Kimbark St. | Longmont | CO | 80501 | MI |
| | Suzanne Beverly Hart | c/o Diane Deutsch<br>848 E. Windsor Dr. | Gilbert | AZ | 85296 | MI |
| T12N - R63W<br>Sec. 23: All | The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083-1100 | MI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Occidental Petroleum Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | WI |
| | Scout Partners, LLC | P.O. Box 1348 | Edmond | OK | 73083- | WI |
| | Fifth Creek Energy Operating Company, LLC | 5251 DTC Parkway, Suite 420 | Greenwood Village | CO | 80111 | WI |
| | Clear Creek Fund I-B, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Pawnee Butte Royalties, LLC | P.O. Box 4631 | Englewood | CO | 80155 | MI |
| | LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | MI |
| | Longs Peak Resources, LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | WI |
| | Overland Energy Partners Fund II, LLC | 700 17th Street, Suite 900 | Denver | CO | 80202 | MI |
| | Wolf Resources, LLC | 621 17th St., Ste 1601 | Denver | CO | 80293 | MI |
| | Oxford Exploration, LLC | 4200 E. 8th Ave., Suite 102 | Denver | CO | 80220 | WI |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | MI / WI |
| | Wyoming Western Oil | P.O. Box 458 | Pine Bluffs | WY | 82082 | ROW |
| | Susan K. Breeden | 2702 19th Street Drive, #17 | Greeley | CO | 80634 | MI |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 | NPRI |
| | McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Halliburton Energy Services, Inc. | 2107 City West Blvd., Building 2 | Houston | TX | 77042 | NPRI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Proved Reserves, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 | MI |
| | Double Eagle Energy Rockies, LLC | 1401 Ballinger Street, Suite 203 | Fort Worth | TX | 76102 | WI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | WI |
| | Mountaintop Minerals | 370 17th St., Ste 5200 | Denver | CO | 80202 | WI |
| | R. K. Pinson & Associates, LLC | 621 17th St., Suite 1555 | Denver | CO | 80293 | WI |
| | Extraction Oil & Gas LLC | 370 17th St., Ste 5200 | Denver | CO | 80202 | WI |
| | Lincoln Energy Partners IV, LLC | 3400 S. Broadway, Suite 100 | Englewood | CO | 80113 | MI |
| | Mary Lou King and Austin Dale King | P.O. Box 476 | Kellogg | ID | 83837 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Incline Niobrar Parnters, L.P. | 5019 N. Central Expressway, Suite B | Dallas | TX | 75205 | WI |
| | SAG Ag, LLC | 58710 County Road 81 | Grover | CO | 80729 | SI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | William J. Breeden, Thomas J. Breeden and Karen Breeden | 3630 Foxcroft Road | Cheyenne | WY | 82001 | MI |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Brighton Mineral Holdings, LLC | P.O. Box 669 | Englewood | CO | 80151-0669 | MI |
| | Superior Oilfield Services Co., LTD | P.O. Box 336356 | Greeley | CO | 80633 | ROW |
| T12N - R63W<br>Sec. 24: All | The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083-1100 | MI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Occidental Petroleum Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Sherryl E. Faris | 2238 Peru Road | Peru | IA | 50222 | MI |
| | Scout Partners, LLC | P.O. Box 1348 | Edmond | OK | 73083- | WI |
| | Johnnie Christensen and Patsy Christensen | 5200 Allan Road | Cheyenne | WY | 82009 | MI |
| | Carolyn Hern and Gerald L Hern | 55 Barstow Bridge Road | Kettle Falls | WA | 99141 | MI |
| | Darlene Hughes | P.O. Box 1115 | Kettle Falls | WA | 99141 | MI |
| | Shirley Melton | 5052 Archer Lane North | Plymouth | MN | 55446 | MI |
| | Dale Mitchell and Judy M. Mitchell | P.O. Box 356 | Lyle | WA | 98635 | MI |
| | Syliva J. Parvin and Robert A. Parvin | P.O. Box 144 | Rock River | WY | 82083 | MI |
| | James Patrick Sullivan and Deanna C. Sullivan | 11413 Glencoe Drive | Cheyenne | WY | 82009 | MI |
| | Albert John Faris and Betty Lou Faris | P.O. Box 53 | Rock River | WY | 82083 | MI |
| | Marjorie Louise Faris Revocable Living Trust dated March 21, 2003<br>Marjorie Louise Faris as Trustee | 1506 Willow Street | San Diego | CA | 92106 | MI |
| | April Sims | 1991 CR 1 #A | McFadden | WY | 82083 | MI |
| | Winnie L. Stephan as Trustee of the Winnie L. Stephan Revocable Trust, dtd December 8, 2011 | P.O. Box 692 | Cheyenne | WY | 82003 | MI |
| | Guy Faris | 179 Indian Ridge Road | Pavillion | WY | 82523 | MI |
| | Patricia R. Walder-Christner | 6907 Willshire Blvd. | Cheyenne | WY | 82009 | MI |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 | NPRI |
| | McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 | WI |
| | Halliburton Energy Services, Inc. | 2107 City West Blvd., Building 2 | Houston | TX | 77042 | NPRI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Proved Reserves, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 | MI |
| | Double Eagle Energy Rockies, LLC | 1401 Ballinger Street, Suite 203 | Fort Worth | TX | 76102 | WI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | WI |
| | R. K. Pinson & Associates, LLC | 621 17th St., Suite 1555 | Denver | CO | 80293 | WI |
| | Extraction Oil & Gas LLC | 370 17th St., Ste 5200 | Denver | CO | 80202 | WI |
| | Michael Sullivan | P.O. Box 1054 | Mesquite | NV | 89024 | MI |
| | Mary Lou King and Austin Dale King | P.O. Box 476 | Kellogg | ID | 83837 | MI |
| | Judy F. Payne and Dale Payne | 41 Dalton Road | Omak | WA | 98841 | MI |
| | Merritt Lacy | 12733 W. Columbine Drive | El Mirage | AZ | 85335 | MI |
| | Incline Niobrar Parnters, L.P. | 5019 N. Central Expressway, Suite B | Dallas | TX | 75205 | WI |
| | Edmond Cook and Tena L. Cook | P.O. Box 1327 | Chadron | NE | 69337 | MI |
| | Wesley J. Faris | 1120 Marcy Street | Ottawa | IL | 61350 | MI |
| | Cindy Jo Hamilton | P.O. Box 214 | Hillsdale | WY | 82060 | MI |
| | Debra Ann Jackson | P.O. Box 75 | Burns | WY | 82053 | MI |
| | Lance Lacy and Tricia Lacy | 15741 W. Ventura Street | Surprise | AZ | 85379 | MI |
| | Grady Faris and Janice Faris | 1854 18th Street | Wheatland | WY | 82201 | MI |
| | Wanda Darlene Hughes | 480 W. 10th Avenue | Kettle Falls | WA | 99141 | MI |
| | Pamela J. Burgener | 19 Nightingale Circle | Camargo | IL | 61919 | MI |
| | Tracey J. Wrobel | 420 Wedgewood Circle | Lake in the Hills | IL | 60156 | MI |
| | Jeffrey C. Mauck | 405 Elm Street | Spring Valley | IL | 61362 | MI |
| | Amy Christine Collins | P.O. Box 1356 | Stenenson | WA | 98648 | MI |
| | Paula Marie Yarger | 4908 F.M. 879 | Palmer | TX | 75152 | MI |
| | Connie Lou Rivas | 751 Avenue C, #45-45 | Cheyenne | WY | 82007 | MI |
| | Jimmie D. Collins | 4408 E. 6th St. | Cheyenne | WY | 82001 | MI |
| | William B. Wilsted and Leanne C. Wilsted | 7378 Augusta Drive | Boulder | CO | 80301 | MI |
| | Apollo Operating, LLC | 1538 Wazee Street, Suite 200 | Denver | CO | 80202 | MI |
| | Fifth Creek Energy Operating Company, LLC | 5251 DTC Parkway, Suite 420 | Greenwood Village | CO | 80111 | WI |
| | Clear Creek Fund I-B, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | JLW Investment, LLC | 351 Glencoe Street | Denver | CO | 80220 | MI |
| | Pawnee Butte Royalties, LLC | P.O. Box 4631 | Englewood | CO | 80155 | MI |
| | LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | MI |
| | Longs Peak Resources, LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | WI |
| | Overland Energy Partners Fund II, LLC | 700 17th Street, Suite 900 | Denver | CO | 80202 | MI |
| | Wolf Resources, LLC | 621 17th St., Ste 1601 | Denver | CO | 80293 | MI |
| | Oxford Exploration, LLC | 4200 E. 8th Ave., Suite 102 | Denver | CO | 80220 | WI |
| | Kent E. Harlan | 822 N. 7th St. | Beatrice | NE | 68310 | ORRI |
| | Debora A. Waymire | 5325 W. Kerry Lane | Glendale | AZ | 85308 | ORRI |
| | Pamela H. Wilson | 644 S. Griffith Park Dr. | Burbank | CA | 91506 | ORRI |
| | Todd D. Harlan | 319 Walnut St. | Hickman | NE | 68372 | ORRI |
| | BFG Minerals, LLC | 225 S. Broadway, Suite 9847 | Denver | CO | 80209 | MI |
| | Principle Energy, L.L.C. | P.O. Box 2228 | Houston | TX | 77252 | MI |
| | Pearlene Hawkins | 470A 2nd St. SW | Albuquerque | NM | 87105 | MI |
| | Faris Hawkins | 2275 Squak Mountain Loop SW | Issaquah | WA | 98027 | MI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | WI |
| | Donna M. Ford as Trustee of the Gary R. Ford and Donna M. Ford Revocable Trust, dated August 26, 2005 | 3840 SR 209 | Boroadview | NM | 88112 | MI |
| | Bert J. Farris | 3931 Granite Street | Cheyenne | WY | 82001 | MI |
| | Joleen Springer | 6241 Donnington Court | Sarasota | FL | 34238 | MI |
| | Lincoln Energy Partners IV, LLC | 3400 S. Broadway, Suite 100 | Englewood | CO | 80113 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Lost River Trading Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | J15, LLC | P.O. Box 31749 | Palm Beach Gardens | FL | 33420 | MI |
| | SAG Ag, LLC | 58710 County Road 81 | Grover | CO | 80729 | SI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Merlyn Charles Faris | Unknown Address | | | | MI |
| | Richard Leigh Faris | 431 Camino De Grato | Sparks | NV | 89441 | MI |
| | Jack Faris | Unknown Address | | | | MI |
| | Judy Likwartz | 5916 N. Wilbur Ave. | Portland | OR | 97217 | MI |
| | Todd Alan Martin and Sydnee Marie Martin as Co-Trustees of the Todd Alan Martin and Sydnee Marie Martin Marital Trust u/t/a dated 11-21-2019 | 169 County Road 148 | Carpenter | WY | 82054 | SI |
| | Bluebird Energy Partners, LLC | 9055 E. Mineral Circle, Suite 110 | Centennial | CO | 80112 | MI |
| | David Lindsey Kirchgessner | 13113 Orienta Avenue NE | Albuquerque | NM | 87123 | MI |
| | Thomas Winter Kirchgessner | 10404 Griffon Drive NW | Albuquerque | NM | 87114 | MI |
| | Laura Lee Bates | 12229 Yellowstone Road NE | Albuquerque | NM | 87111 | MI |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | MI / WI |
| | JP Morgan Chase Bank, N.A. | 1125 17th St., Floor 2 | Denver | CO | 80202 | MTG |
| | Raisa II, LLC | 1560 Broadway, Suite 250 | Denver | CO | 80202 | WI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Zachary Gleit, Trustee of the Roberta Gleit Revocable Trust dated February 24, 2018 | 755 West End Ave. #6C | New York | NY | 10025 | MI |
| T13N - R62W<br>Sec. 19: NE | Charlene K. Gordon and John G. Gordon | 796 Road 154 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Farm Credit Services of America, FLCA | 5015 S. 118th Street | Omaha | NE | 68103-2409 | MTG |
| T13N - R62W<br>Sec. 19: Lots 1, 2, E2NW | Ivan L. Kranz and Kimberly K. Kranz Joint Rev Trust | P.O. Box 129 | Burns | WY | 82053 | SI |
| | Lorraine Smith | 4696 CR 204 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R62W<br>Sec. 19: Lots 3, 4, E2SW | Lucinda I. Smith | 4890 CR 205 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R62W<br>Sec. 19: SE | Edwin K. Smith, Jr. and Lucinda I. Smith, husband and wife | 4890 CR 205 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R62W<br>Sec. 30: NE | Earl Eugene Noel & Donna C. Noel | P.O. Box 639 | Martin | SD | 57551 | SI |
| | Donna Rogers and Jeffrey Douglas | 707 S. Table Mountain Loop | Cheyenne | WY | 82009 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | The State Highway Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 | ROW |
| | Rampike Resources, Ltd. | 730 17th Street, Suite 370 | Denver | CO | 80202 | MI |
| | TRP Minerals, LLC | 4545 Post Oak Place, Suite 240 | Houston | TX | 70277 | MI |
| | Exodus Energy, LLC | 1474 S. Saint Paul St. | Denver | CO | 80210 | MI |
| | CECO, LLC | P.O. Box 102076 | Denver | CO | 80250 | MI |
| T13N - R62W<br>Sec. 30: Lots 1, 2, E2NW | Oscar E. Orozco and Michelle M. Orozco | 4807 Road 205 | Carpenter | WY | 82054 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | The State Highway Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 | ROW |
| | Kathleen Kay Arp Woolbright | 311 S. Tennessee St. | Amarillo | TX | 79106 | MI |
| | Adrian Lynn Arp | P.O. Box 703 | Filer | ID | 83328 | MI |
| | Gregory Gene Arp | Box 332 | Bennet | NE | 68317 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R62W<br>Sec. 30: Lots 3, 4, E2SW | Gary R and Donna M. Ford Revocable Trust | 3840 SR 209 | Broadview | NM | 88112 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | The State Highway Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R62W<br>Sec. 30: SE | Gary R and Donna M. Ford Revocable Trust | 3840 SR 209 | Broadview | NM | 88112 | SI / MI |
| | Donna Rogers and Jeffrey Douglas | 707 S. Table Mountain Loop | Cheyenne | WY | 82009 | SI |
| | Rampike Resources, Ltd. | 730 17th Street, Suite 370 | Denver | CO | 80202 | MI |
| | TRP Minerals, LLC | 4545 Post Oak Place, Suite 240 | Houston | TX | 70277 | MI |
| | Exodus Energy, LLC | 1474 S. Saint Paul St. | Denver | CO | 80210 | MI |
| | CECO, LLC | P.O. Box 102076 | Denver | CO | 80250 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | The State Highway Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 | ROW |
| T13N - R62W<br>Sec. 31: NE | Richard R. Whited Living Trust | 3670 Columbia Falls Stage | Columbia Falls | MT | 59912 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | MI / ROW |
| | State of Wyoming<br>Office of State Lands & Investments | Herschler Building<br>122 W. 25th Street - W103 | Cheyenne | WY | 82002 | ROW |
| T13N - R62W<br>Sec. 31: Lots 1, 2, E2NW | Gary R and Donna M. Ford Revocable Trust | 3840 SR 209 | Broadview | NM | 88112 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | MI / ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| T13N - R62W<br>Sec. 31: Lots 3, 4, E2SW | Joshua C. Rohde | 4834 Road 203 | Carpenter | WY | 82054 | SI |
| | Anadarko Land Corp., a Nebraska corporation, formerly Union Pacific Land Resources Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | ROW |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Roger Jewell | 4853 Monroe Ave | Carpenter | WY | 82054 | SI |
| | Roger Jewell | 4857 Monroe Ave | Carpenter | WY | 82054 | SI |
| | Dennis J Seidl | 4846 Monroe Ave | Carpenter | WY | 82054 | SI |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Evergreen Pipeline, Inc | 4842 Road 203 | Carpenter | WY | 82054 | SI |
| | Cory Morgan and Heather Morgan | 313 2nd Street | Carpenter | WY | 82054 | SI |
| | Scott Morgan and Denise Morgan | 312 2nd St. | Carpenter | WY | 82054 | SI |
| | Jeffrey E. Spence Revocable Trust | 4816 Road 203 | Carpenter | WY | 82054 | SI |
| | Carpenter Cemetery | Road 204 | Carpenter | WY | 82054 | SI |
| | Grace Valley, LLC | 316 E. 1st Street | Carpenter | WY | 82054 | SI |
| | In God We Trust No 1 Revocable Trust<br>In God We Trust No 2 Revocable Trust | 324 County Road 148 | Carpenter | WY | 82054 | SI |
| | Jason W. Smith and Lisa J. Smith | P.O. Box 401 | Carpenter | WY | 82054 | SI |
| | Laramie County School District No. 2 | 4814 Monroe Ave | Carpenter | WY | 82054 | SI |
| | Kristy Jean McKinney | 348 N 1st St. | Carpenter | WY | 82054 | SI |
| | Donald A. Syvanen and Mary Ann Syvanen | P.O. Box 472 | Carpenter | WY | 82054 | SI |
| | Kathy Marie Hammons | 4840 Adams Ave. | Carpenter | WY | 82054 | SI |
| | Cassandra Carroll, c/o Lindvall Neil | 4838 Monroe Avenue | Carpenter | WY | 82054 | SI |
| | Cassandra Carroll, c/o Lindvall Neil | 208 E. Prosser Rd. | Cheyenne | WY | 82007 | SI |
| | Karen Ankers | 4836 Monroe Avenue | Carpenter | WY | 82054 | SI |
| | Carol M. Bradley Living Trust | 1951 Fern Court | Kissimmee | FL | 34743 | SI |
| | Jerry L. Burnett and Margaret E. Burnett | P.O. Box 4 | Hereford | CO | 80732 | SI |
| | Burnett Land & Livestock, Ltd. | 5453 County Road 202 | Carpenter | WY | 82054 | SI |
| | Jerry L. Burnett and Margaret E. Burnett | 4834 Monroe Avenue | Carpenter | WY | 82054 | SI |
| | James Michael Morris | 2121 Redhead Dr | Johnstown | CO | 80534 | SI |
| | Russell D. Matz and Bettyanne M. Haines | 4831 Monroe Avenue | Carpenter | WY | 82054 | SI |
| | Don S. Poelma and Gayle L. Poelma | 6515 Armant Ct | Cheyenne | WY | 82009 | SI |
| | Joyce P. Andrews | 4825 Monroe Avenue | Carpenter | WY | 82054 | SI |
| | Jon J. Dalton | 335 N 1st | Carpenter | WY | 82054 | SI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Mark E. Goehring and Karen J. Goehring | 336 N 1st | Carpenter | WY | 82054 | SI |
| | Carpenter Christian Fellowship Church | 4858 Adams Ave | Carpenter | WY | 82054 | SI |
| | Ezra Derstine c/o Matthew Derstine | 331 Second Street | Carpenter | WY | 82054 | SI |
| | Lynn Warner, Matthew Yoder and Janel Yoder | 332 3rd Street | Carpenter | WY | 82054 | SI |
| | Evans Community Park | P.O. Box O | Carpenter | WY | 82054 | SI |
| | St Peters Church | 316 4th Street | Carpenter | WY | 82054 | SI |
| | David J. Leastman and Lorayne A. Leastman | 4849 E. Adams Avenue | Carpenter | WY | 82054 | SI |
| | Marcia Lea Leastman | 4845 E. Adams Avenue | Carpenter | WY | 82054 | SI |
| | John Ferrera | 4833 Adams Avenue | Carpenter | WY | 82054 | SI |
| | Billy Nokes and Emily Nokes | 315 2nd Street | Carpenter | WY | 82054 | SI |
| | Cory Morgan and Heather Morgan | 313 2nd Street | Carpenter | WY | 82054 | SI |
| | Scott Morgan and Denise Morgan | 313 2nd Street | Carpenter | WY | 82054 | SI |
| | Leo Smith and Janet Smith | 115 Road 153 | Carpenter | WY | 82054 | SI |
| | Todd Alan Martin and Sydnee Marie Martin as Co-Trustees of the Todd Alan Martin and Sydnee Marie Martin Marital Trust u/t/a dated 11-21-2019 | 169 County Road 148 | Carpenter | WY | 82054 | SI |
| | Roberta Lee May | 1251 Road 7 | Pine Bluffs | WY | 82082 | SI |
| | Carpenter Water and Sewer District | P.O. Box 433 | Carpenter | WY | 82054 | SI |
| | Scott Thums and Elizabeth Thums | P.O. Box 372 | Carpenter | WY | 82054 | SI |
| | Marvin K. Stuart and Larita P. Stuart | 326 2nd St | Carpenter | WY | 82054 | SI |
| | Leona I Price | P.O. Box 161 | Burns | WY | 82053 | SI |
| | J.R. Carpenter c/o Evans Park Board | P.O. Box 5 | Carpenter | WY | 82054 | SI |
| | Laramie County Fire Protection Dist 4 | P.O. Box 5 | Carpenter | WY | 82054 | SI |
| | Paul M. Gonzales and Erin M. Gonzales | 4821 Main Ave. | Carpenter | WY | 82054 | SI |
| | Lonnie D. Fiscus and Marjorie A. Fiscus | 4834 Main Street | Carpenter | WY | 82054 | SI |
| | Reese Burnett and Hannah Burnett | 4840 Adams Ave. | Carpenter | WY | 82054 | SI |
| | Larry Williams, Penny E. Martin and Vera E. Williams | 4832 Adams Ave | Carpenter | WY | 82054 | SI |
| | Blaine W. Barker | 4834 Adams Ave | Carpenter | WY | 82054 | SI |
| | Kevin J. Dobbs and Jami L. Dobbs | 324 Main Street | Carpenter | WY | 82054 | SI |
| | Ruby Pearl True | Unknown Address | | | | SI |
| | Cheyenne Light, Fuel and Power Company | P.O. Box 1409 | Cheyenne | WY | 82003 | ROW |
| | The Mountain States Telephone and Telegraph Company | 931 14th Street | Denver | CO | 80202 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | New West Bank | 55 S Elm Avenue | Eaton | CO | 80615 | MTG |
| | Larry J. Lembitz and Diana L. Lembitz | Unknown Address | | | | SI |
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| T13N - R62W<br>Sec. 31: SE | Richard R. Whited Living Trust | 3670 Columbia Falls Stage | Columbia Falls | MT | 59912 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | ROW |
| | Leo Smith and Janet Smith | 115 Road 153 | Carpenter | WY | 82054 | SI |
| | Dennis J Seidl | 4846 Monroe Ave | Carpenter | WY | 82054 | SI |
| | David John Leastman II and Regina Raye Leastman | 320 5th Street | Carpenter | WY | 82054 | SI |
| | David J. Leastman and Lorayne A. Leastman | 4849 E. Adams Avenue | Carpenter | WY | 82054 | SI |
| | John A. Barela Revocable Trust | 314 5th St | Carpenter | WY | 82054 | SI |
| | Evergreen Pipeline, Inc | 4842 Road 203 | Carpenter | WY | 82054 | SI |
| | The Transportation Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 | ROW |
| | State of Wyoming<br>Office of State Lands & Investments | Herschler Building<br>122 W. 25th Street - W103 | Cheyenne | WY | 82002 | ROW |
| | The Mountain States Telephone and Telegraph Company | 931 14th Street | Denver | CO | 80202 | ROW |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| T13N - R63W<br>Sec. 14: S2 | Carol M. Bradley Living Trust | 1951 Fern Court | Kissimmee | FL | 34743 | SI |
| | 293Frog, LLC | 7551 Bocage Boulevard | Baton Rouge | LA | 70809 | MI |
| | Charles W. Austin | P.O. Box 1153 | Billings | MT | 59103 | MI |
| | T. F. Hodge | 1605 Continental Bank Building | Fort Worth | TX | 76102 | MI |
| | ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 | MI |
| | Jill Jahn, aka Jill Tower aka Jill F. Tower | P.O. Box 156 | Fishtail | MT | 59222 | MI |
| | Keith Tower and Martha J. Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 | MI |
| | Alice G. Tower | 2434 Rancho Road | Billings | MT | 59102 | MI |
| | Shandera3, LLC | 3733 Gunsmoke Road | Cheyenne | WY | 82001 | MI |
| | Rodney E. and Sylvia M. Girmus | 7067 Road 47F | Torrington | WY | 82240 | MI |
| | Bryon P. and Peggy A. Veal | 5855 East 124th | Brighton | CO | 80601 | MI |
| | Mark C. and Laura E. Anzman, Co-Trustees of the Mark and Laura Anzman Living Trust, dated 5/8/2013 | 4655 County Road 207 | Carpenter | WY | 82054 | MI |
| | Cox Minerals LLC | P.O. Box 2015 | Billings | MT | 59103-2015 | MI |
| | Raymond L. and Diana L. Martin | 4691 County Road 207 | Carpenter | WY | 82054 | MI |
| | Sharon K. Miller and Brent L (Nidelkoff) Piscitello | 1722 Cheshire Drive | Cheyenne | WY | 82001 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Michael Schreiner, Successor Trustee of the Lois M. Schreiner Trust Agreement, dated 7/25/2006 | 416 Cody | Cheyenne | WY | 82009 | MI |
| | Gary A. Weber and Christine D. Weber | 4619 County Road 207 | Carpenter | WY | 82054 | MI |
| | Maureen J. Shandera, Trustee of the Maureen J. Shandera Revocable Trust, dated 5/20/1998 | 5192 Road 207 | Carpenter | WY | 82054 | MI |
| | Sherry Cox Dupee | 105 Fair Acres Road | Oxford | England | OX4 - 1 TQ | MI |
| | Harold V. Stroot and Cynthia K. Stroot | P.O. Box 76 | Burns | WY | 82053 | MI |
| | Maxine B. Morgan | 8310 Heather Avenue | Eden Prairie | MN | 55347 | MI |
| | Jeffery W. Hamel | 8310 Heather Avenue | Eden Prairie | MN | 55347 | MI |
| | B. Frank Brady | Unknown Address | | | | MI |
| | Cynthia K. and Harold V. Stroot | Unknown Address | | | | MI |
| | Janice Ann Taylor aka Jan Taylor aka Janice A. Taylor | 636 E. Magnesium Rd. Apt C-111 | Spokane | WA | 99208 | MI |
| | Ralph V. Kent | Unknown Address | | | | MI |
| | Howard and Elsie Rose Evans | Unknown Address | | | | MI |
| | Virginia G. Newman | Unknown Address | | | | MI |
| | Jimmy Lee Alexander | P.O. Box 178 | Kingfisher | OK | 73750 | MI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Renegade Resources, LLC c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R63W<br>Sec. 15: All | Shawn P. and Brandi Halls | 1708 County Road 136 | Cheyenne | WY | 82009 | SI |
| | Patricia A and Peter C. Gassner, Jr. | 4567 County Road 207 | Carpenter | WY | 82054 | SI |
| | Craig and Alaina Goble | 1480 Gilchrist Road | Cheyenne | WY | 82009 | SI |
| | Red Baldy Ranch | 785 Road 140 | Carpenter | WY | 82054 | SI |
| | Martin Wissner, Trustee, and his successor in trust, under the Martin Wissner Living Trust, dated 5/31/2019, for the benefit of Martin Wissner and his heirs | 620 Road 146 | Carpenter | WY | 82054 | SI |
| | Jeremy Russell and Tanya Marie Evans | 5680 Road 228 | Albin | WY | 82050 | SI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Phillip M. Brandt and Lorraine S. Brandt | 3153 Bluff Place | Cheyenne | WY | 82009 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Thomas S. Harrower, Jr. | 8603 Powderhouse Road | Cheyenne | WY | 82009 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Farm Service Agency | 1502 Progress Court | Wheatland | WY | 82201 | MTG |
| | Bank of the West | 2200 East Lincoln Way | Cheyenne | WY | 82001 | MTG |
| | Meridian Trust Federal Credit Union | P.O. Box 548 | Cheyenne | WY | 82003 | MTG |
| | Jonah Bank of Wyoming | 777 West 1st Street | Casper | WY | 82601 | MTG |
| | Platte Valley Bank | 421 Vandehei Avenue | Cheyenne | WY | 82009-6103 | MTG |
| T13N - R63W<br>Sec. 20: All | Michael W. and Dorothy M. Anthony | 595 County Road 143 | Carpenter | WY | 82054 | SI |
| | Terry L. Nachtman | 581 Road 143 | Carpenter | WY | 82054 | SI |
| | Harrower Ranches LLC | 8603 Powderhouse Road | Cheyenne | WY | 82009 | SI / MI |
| | Joseph and Allison Ward | 535 Road 143 | Carpenter | WY | 82054 | SI |
| | United States of America / Bureau of Land Management | 5353 Yellowstone Road | Cheyenne | WY | 82009 | MI |
| | Lillian E. Harrower Revocable Mineral Trust, dated 11/2/2007 | 8603 Powderhouse Road | Cheyenne | WY | 82009 | MI |
| | Mary Christine Dorr and Susan Lee Snyder | Unknown Address | | | | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Trading River Trading Company | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Raymond Z. and Mildred E. Nolt | 535 Road 143 | Carpenter | WY | 82054 | MI |
| | AK Resources, LLC | P.O. Box 6975 | Denver | CO | 80206 | MI |
| | ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 | MI |
| | Jill Jahn, aka Jill Tower aka Jill F. Tower | P.O. Box 156 | Fishtail | MT | 59222 | MI |
| | Keith Tower and Martha J. Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 | MI |
| | Lincoln Energy Partners, LLC | 852 Broadway, Suite 300 | Denver | CO | 80203 | MI |
| | Community Investments, Inc. | P.O. Box 653 | Cheyenne | WY | 82003 | MI |
| | Zora N. Montgomery | 816 South 216th Street, T311 | Des Moines | WA | 98198 | MI |
| | Gene E. Miller | P.O. Box 68 | Chappell | NE | 69129 | MI |
| | Terry L. Nachtman | 581 Road 143 | Carpenter | WY | 82054 | MI |
| | 293Frog, LLC | 7551 Bocage Boulevard | Baton Rouge | LA | 70809 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Harrower Ranches LLC | 8603 Powderhouse Road | Cheyenne | WY | 82054 | MI |
| | BEIF #2, LLC | 475 17th Street, Suite 570 | Denver | CO | 80202 | MI |
| | John S. Belcher, LLC | 235 South High Street | Denver | CO | 80209 | MI |
| | Michael W. and Dorothy M. Anthony | 595 County Road 143 | Carpenter | WY | 82054 | MI |
| | Cox Minerals LLC | P.O. Box 2015 | Billings | MT | 59103-2015 | MI |
| | Sherry Cox Dupee | 105 Fair Acres Road | Oxford | England | OX4 - 1 TQ | MI |
| | Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Lost River Trading Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Lillian E. Harrower Revocable Mineral Trust, dated 11/2/2007 | 8603 Powderhouse Road | Cheyenne | WY | 82009 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Production Credit Association of the Midlands | P.O. Box J | Torrington | WY | 82240 | MTG |
| | First Interstate Bank | P.O. Box 1098 | Torrington | WY | 82240 | MTG |
| | Freedom Mortgage Corporation | 951 Yamoto Road, Suite 175 | Boca Raton | FL | 33431 | MTG |
| T13N - R63W<br>Sec. 21: All | Harrower Ranches LLC | 8603 Powderhouse Road | Cheyenne | WY | 82009 | SI / MI |
| | Robert Gin and Rebekah Tan, Trustees of The Tan-Gin Family Trust, dated 9/1/2004 | 2568 West Overton Ridge Place | Tucson | AZ | 85742 | SI |
| | Jerry E. and Roxie C. Anderson | 4455 Teepee Road | Carpenter | WY | 82054-9109 | SI |
| | Michael R. Calaway and Vickie L. Hintze | 4487 Teepee Road | Carpenter | WY | 82054 | SI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Phillip M. Brandt and Lorraine S. Brandt | 3153 Bluff Place | Cheyenne | WY | 82009 | MI |
| | Gene E. Miller | P.O. Box 68 | Chappell | NE | 69129 | MI |
| | Janet Iokepa | 415 Keonaona Street | Hilo | HI | 96720 | MI |
| | Heather Montgomery | 3907 East 12th | Spokane | WA | 99202 | MI |
| | Jared Montgomery | 3907 East 12th | Spokane | WA | 99202 | MI |
| | Keith E. Montgomery | 305 Ave A | Battle Creek | MI | 49015 | MI |
| | Susan Olson-Miller | Unknown Address | | | | MI |
| | Martin Jacob Miller | Unknown Address | | | | MI |
| | Amanda Jo Miller- McClanahan | Unknown Address | | | | MI |
| | BHCH Mineral, Ltd. | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Fredericksburg Royalty, Ltd | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Curzon Management, LLC | 1116 Wiltshire Avenue | San Antonio | TX | 78209 | MI |
| | Anadarko Oil & Gas 5, LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Thomas Harrower, Jr. and Lillian Harrower | 8603 Powderhouse Road | Cheyenne | WY | 82009 | ROW |
| | Western Vistas FCU | 3207 Sparks Road | Cheyenne | WY | 82001 | MTG |
| T13N - R63W<br>Sec. 22: All | Roy V. and Linda L. Beaver | 1104 Maddison Avenue | Cheyenne | WY | 82001 | SI |
| | Jonea R. Fuller and James L. Fuller | 285 Crossbow Dr | Green River | WY | 82935 | SI |
| | Marilyn K. Machay c/o Marilyn K. Detillion | 7004 Denise Road | Cheyenne | WY | 82009 | SI |
| | Jeffery L. and Melissa A. Matney | 4514 Teepee Road | Carpenter | WY | 82054 | SI |
| | Nicole and Richard Lorh | 4507 Teepee Road | Carpenter | WY | 82054 | SI |
| | Dallas C. Harrigfeld | P.O. Box 20303 | Cheyenne | WY | 82003 | SI |
| | Cody E. and Laura Jo Howes | 4566 Buggy Road | Carpenter | WY | 82054 | SI |
| | Justin A. and Karen A. Morrison | 512 Road 146 | Carpenter | WY | 82054 | SI |
| | Joanne E. Brown-Vossler | 1030 Washington Street | Douglas | WY | 82633 | SI |
| | Jason and Mona Castle | 4528 Buggy Road | Carpenter | WY | 82054 | SI |
| | Sage Farms, LLC | 1595 Tanaka Drive | Erie | CO | 80516 | SI / MI |
| | Larry E. Seitz M.D., Trustee of the Larry E. Seitz Revocable Trust, dated 3/11/1981 | 219 Palm Springs Avenueast | Cheyenne | WY | 82009 | SI / MI |
| | Christopher H. and Amy Lynn Clark | 4533 Teepee Road | Carpenter | WY | 82054 | SI / MI |
| | Roger N. and Eddy Linda Stearns | 4539 Buggy Road | Carpenter | WY | 82054 | SI / MI |
| | Maureen T. Moore | 4511 Buggy Road | Carpenter | WY | 82054 | SI / MI |
| | Cox Minerals LLC | P.O. Box 2015 | Billings | MT | 59103 | MI |
| | BHCH Mineral, Ltd. | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Fredericksburg Royalty, Ltd | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Curzon Management, LLC | 1116 Wiltshire Avenue | San Antonio | TX | 78209 | MI |
| | Nicole and Richard Lorh | 4507 Teepee Road | Carpenter | WY | 82054 | MI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | MI |
| | Renegade Exploration, LLC | 1625 Broadway, Suite 830 | Denver | CO | 80202 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | 293Frog, LLC | 7551 Bocage Boulevard | Baton Rouge | LA | 70809 | MI |
| | ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 | MI |
| | Jill Jahn, aka Jill Tower aka Jill F. Tower | P.O. Box 156 | Fishtail | MT | 59222 | MI |
| | Keith Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 | MI |
| | Janice Ann Taylor aka Jan Taylor aka Janice A. Taylor | 636 E. Magnesium Rd. Apt C-111 | Spokane | WA | 99208 | MI |
| | Ross M. Taylor | 34752 Bachelor Flat Road | St. Helens | OR | 97051 | MI |
| | Kimberly T. Dunn | 2631 W. Dell Drive | Spokane | WA | 99208 | MI |
| | Sherry Cox Dupee | 105 Fair Acres Road | Oxford | England | OX4 - 1 TQ | MI |
| | Harrower Ranches LLC | 8603 Powderhouse Road | Cheyenne | WY | 82009 | MI |
| | Charles Y. Lu and Felice S. Huang | P.O. Box 20303 | Cheyenne | WY | 82303 | MI |
| | Jeffrey L. and Melissa A. Matney | 4514 Teepee Road | Carpenter | WY | 82054 | MI |
| | John and Mona Castle | 4528 Buggy Road | Carpenter | WY | 82054 | MI |
| | J. E. Taylor | 1925 Grand Avenue | Billings | MT | 59102 | MI |
| | Charles W. Austin | P.O. Box 1153 | Billings | MT | 59103 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Donald A. and Stacy L. Edgar | 17892 Bagby Road | Green Ridge | MO | 65332 | MI |
| | Cody E. and Laura Jo Howes | 9039 South Greenspoint Lane | Highlands Ranch | CO | 80130 | MI |
| | Wyoming Bank & Trust | 5827 Yellowstone Road | Cheyenne | WY | 82009 | MI |
| | Justin A. and Karen A. Morrison | 512 Road 146 | Carpenter | WY | 82054 | MI |
| | Robert P. Korber Revocable Trust | 1725 Eagle Drive | Cheyenne | WY | 82009 | MI |
| | Jeffery C. and Danielle D. Hackett | 4566 Buggy Road | Carpenter | WY | 82054 | MI |
| | Alice Jones | Unknown Address | | | | MI |
| | Linda Edgar | Unknown Address | | | | MI |
| | Roseshell A. Ward | Unknown Address | | | | MI |
| | Cassandra J. Ward | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Charlotte L. Sharp | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Manuel Blanco, IIII | Unknown Address | | | | MI |
| | Ruth M. and John P. Rome | 6516 Hedge Lane Terrace, Apt. # 106 | Shawnee | KS | 66226 | MI |
| | Charles Edgar | Unknown Address | | | | MI |
| | Ruth Enfield Edgar | Unknown Address | | | | MI |
| | Misty Tinney & Roy V. Beaver, Jr. | Unknown Address | | | | MI |
| | Mary Christine Dorr and Susan Lee Snyder | Unknown Address | | | | MI |
| | Joanne E. Brown-Vossler | 1030 Washington Street | Douglas | WY | 82633 | MI |
| | Roger N. and Eddy Linda Stearns | 4539 Buggy Road | Carpenter | WY | 82054 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Thomas S. Harrower, Jr. | 8603 Powderhouse Road | Cheyenne | WY | 82009 | ROW |
| | Guild Mortgage Company | 5898 Copley Drive | San Diego | CA | 92111 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | UniWyo Federal Credit Union | 2020 E. Grand Avenue, Suite 100 | Laramie | WY | 82070 | MTG |
| | Blue Federal Credit Union | P.O. Box 3200 | Cheyenne | WY | 82003 | MTG |
| | United Wholesale Mortgage, LLC | 585 South Boulevard E | Pontiac | MI | 48341 | MTG |
| | First Interstate Bank | 401 W. 9th Street | Cheyenne | WY | 82001 | MTG |
| | Wells Fargo Bank , N.A. | P.O. Box 11701 | Newark | NJ | 07101-4701 | MTG |
| | Wyoming Community Development Authority | 155 North Beech | Casper | WY | 82602 | MTG |
| T13N - R63W<br>Sec. 23: All | Travis and Christy Wilson | 4661 Road 206 | Carpenter | WY | 82054 | SI |
| | Mahegge, LLC | P.O. Box 1416 | Mills | WY | 82644 | SI |
| | Caldwell Banker The Property Exchange | 255 Storey Boulevard | Cheyenne | WY | 82009 | SI |
| | Leaning Tree Homes, Inc. | 1740 Dell Range Boulevard, Suite 423 | Cheyenne | WY | 82009 | SI |
| | Randy Lynn and Victoria Lynn Ackerman | 6519 Kyle Avenue | Fort Collins | CO | 80525 | SI |
| | Kevin and Lynn Emery | 4613 Road 206 | Carpenter | WY | 82054 | SI |
| | Marie E. Bachofer | 4643 Road 206 | Carpenter | WY | 82054 | SI / MI |
| | Stanley D. and Jennifer L. Baer | 4644 Road 204 | Carpenter | WY | 82054 | SI |
| | Leroy and Marilyn Wiens | 511 Road 146 | Carpenter | WY | 82054 | SI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Max E. True and Judy V. True | 4625 County Road 206 | Carpenter | WY | 82054 | MI |
| | Bulldog Energy , LLC | 2460 W. Caithness Place, Unit 207 | Denver | CO | 80211 | MI |
| | Westland Holdings, Inc. | P.O. Box 653 | Cheyenne | WY | 82003 | MI |
| | Rearden Minerals, LLC | 5914 W. Courtyard Drive | Austin | TX | 78730 | MI |
| | Acoma Energy, LLC | 3801 E. Florida Avenue, Suite 508 | Denver | CO | 80210 | MI |
| | TAPS I Energy, LLC | 1001 Farmington Avenue, Suite 200 | West Hartford | CT | 06107 | MI |
| | Beth and Ken Karmin Family Trust | 1555 Capri Drive | Pacific Palasades | CA | 90272 | MI |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Quicken Loans, LLC | 1050 Woodward Avenue | Detroit | MI | 48226-1906 | MTG |
| | Cherry Creek Mortgage, LLC | 7600 East Orchard Road, Suite #250-N | Greenwood Village | CO | 80111 | MTG |
| | First Interstate Bank | P.O. Box 1710 | Cheyenne | WY | 82001-1710 | MTG |
| T13N - R63W<br>Sec. 24: All | M&P Concrete, Inc. | P.O. Box 2096 | Cheyenne | WY | 82003 | SI |
| | Burdine W. Rogers, Jr. | 4771 Road 206 | Carpenter | WY | 82054 | SI |
| | Anthony Haar and Sheralee Clark | 4765 Road 206 | Carpenter | WY | 82054 | SI |
| | Jeffery William and Daniella LeNea Allman | 4761 Road 206 | Carpenter | WY | 82054 | SI / MI |
| | Linda L. Lankford | 4573 Road 206 | Carpenter | WY | 82054 | SI |
| | G & G Enterprises of WY, LLC | 255 Storey Boulevard | Cheyenne | WY | 82009 | SI |
| | Leaning Tree Homes, Inc. | 1740 Dell Range Boulevard, Suite 423 | Cheyenne | WY | 82009 | SI |
| | Richard Philip and Leanne Vannaman | 3337 Alexander Avenue | Cheyenne | WY | 82001 | SI |
| | Charles Y. Lu and Felice S. Huang | P.O. Box 20303 | Cheyenne | WY | 82003 | SI |
| | Mahegge, LLC | P.O. Box 1416 | Mills | WY | 82644 | SI |
| | Keke Lu and Yong Cao | 6 Myrtle Dr | Acton | MA | 01720 | SI |
| | JKW, LLC | 255 Storey Boulevard | Cheyenne | WY | 82009 | SI |
| | Abigail and Kevin Oblak | 5426 Sagebrush Avenue | Cheyenne | WY | 82009 | SI |
| | Maxine Soppe | P.O. Box 2778 | Cheyenne | WY | 82003 | SI |
| | David Bruce Soppe Living Trust | P.O. Box 4 | Kaycee | WY | 82639 | SI |
| | Burdine W. Rogers, Jr. | 4771 Road 206 | Carpenter | WY | 82054 | MI |
| | Arrow Energy, LLC | 809 W. 3rd Street | McCook | NE | 69001 | MI |
| | Gary and Karen McCallister | Unknown Address | | | | MI |
| | Weston Eugene Cochran | 609 Ash Street | Fort Morgan | CO | 80701 | MI |
| | M&P Concrete, Inc. | P.O. Box 2096 | Cheyenne | WY | 82003 | MI |
| | Grayrock Minerals, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 | MI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | MI |
| | Mahegge, LLC | P.O. Box 1416 | Mills | WY | 82644 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Lost River Trading Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | Anthony Haar and Sheralee Clark | 4765 Road 206 | Carpenter | WY | 82054 | MI |
| | John Dean | P.O. Box 1028 | Gilmer | TX | 75644 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | John Scott Gibson and Judy A. Gibson | 16838 Morgan Road 10 | Fort Morgan | CO | 80701 | MI |
| | Linda L. Lankford | 4573 Road 206 | Carpenter | WY | 82054 | MI |
| | Maxine Soppe | 504 Road 148 | Carpenter | WY | 82054 | MI |
| | Lucinda I. Smith | 4890 CR 205 | Carpenter | WY | 82054 | MI |
| | Lorraine Smith | 4696 CR 204 | Carpenter | WY | 82054 | MI |
| | Mary Soppe | 5145 Clifford Avenue | Las Cruces | NM | 88012 | MI |
| | Michael Soppe | Unknown Address | | | | MI |
| | Lloyd W. Hammond | Unknown Address | | | | MI |
| | James A. Hammond | Unknown Address | | | | MI |
| | Mable O. Gustafson | Unknown Address | | | | MI |
| | Charles R. Hammond | Unknown Address | | | | MI |
| | Patricia Hammond | Unknown Address | | | | MI |
| | William Collicott, as PR for the Estate of Melvin L. Collicott | Unknown Address | | | | MI |
| | First Interstate Bank | P.O. Box 1710 | Cheyenne | WY | 82003-1710 | MTG |
| | WyHy Federal Credit Union | 1715 Stillwater Avenue | Cheyenne | WY | 82009 | MTG |
| | Rocket Mortgage, LLC fka Quicken Loans | 1050 Woodward Avenue | Detroit | MI | 48226-1906 | MTG |
| | Bank of America | 101 South Tryon Street | Charlotte | NC | 28255 | MTG |
| | Platte Valley Ag Credit Co. | P.O. Box 790 | Torrington | WY | 82240 | MTG |
| T13N-R63W<br>Sec. 25: All | Maxine Soppe | P.O. Box 2778 | Cheyenne | WY | 82003 | SI |
| | Jeff and Molly Williams Family Revocable Family Trust | 1418 E 21st Street | Cheyenne | WY | 82001 | SI |
| | Brenda Jo Millikin | 4727 Road 205 | Carpenter | WY | 82054 | SI |
| | Stanley D. and Jennifer L. Baer | 4644 Road 204 | Carpenter | WY | 82054 | SI |
| | Smith and Jones, LLC c/o Jimmy V. Jones | 678 Sand Castle Way | Mesquite | NV | 89027 | SI |
| | Gary Smith Family Living Trust | P.O. Box 26 | Hereford | CO | 80732 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Smith & Jones, LLC | 6102 East Hwy 30 | Cheyenne | WY | 82001 | MI |
| | Mary Maxine Soppe | 504 Road 148 | Carpenter | WY | 82054 | MI |
| | Lucinda I. Smith | 4890 CR 205 | Carpenter | WY | 82054 | MI |
| | Lorraine Smith | 4696 CR 204 | Carpenter | WY | 82054 | MI |
| | Mary Soppe | 5145 Clifford Avenue | Las Cruces | NM | 88012 | MI |
| | David Soppe | P.O. Box 4 | Kaycee | WY | 82639 | MI |
| | Michael Soppe | Unknown Address | | | | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | Oneonta Resources, LLC | 5228 Lonetree Drive | Loveland | CO | 80537 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Anadarko Oil & Gas 5, LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| T13N - R63W<br>Sec. 26: All | Brenda Jo Millikin | 4727 Road 205 | Carpenter | WY | 82054 | SI / MI |
| | Stanley D. and Jennifer L. Baer | 4644 Road 204 | Carpenter | WY | 82054 | SI / MI |
| | Gary Smith Family Living Trust | P.O. Box 26 | Hereford | CO | 80732 | SI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Mary Maxine Soppe | 504 Road 148 | Carpenter | WY | 82054 | MI |
| | Lucinda I. Smith | 4890 CR 205 | Carpenter | WY | 82054 | MI |
| | Lorraine Smith | 4696 CR 204 | Carpenter | WY | 82054 | MI |
| | Mary Soppe | 5145 Clifford Avenue | Las Cruces | NM | 88012 | MI |
| | David Soppe | P.O. Box 4 | Kaycee | WY | 82639 | MI |
| | Michael Soppe | Unknown Address | | | | MI |
| | Arrow Energy, LLC | 809 W. 3rd Street | McCook | NE | 69001 | MI |
| | Oneonta Resources, LLC | 5228 Lonetree Drive | Loveland | CO | 80537 | MI |
| | Thomas W. Stagg | 1309 Ironwood Street | Boulder City | NV | 89004 | MI |
| | Mark R. Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | David F. Stagg | 9609 239th Street North | Port Byron | IL | 61275 | MI |
| | Elenor Stagg King | P.O. Box 3033 | Clinton | IA | 52732 | MI |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | ORRI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Laramie Operating LLC, a Colorado limited liability company | 1120 Lincoln Street, Suite 1605 | Denver | CO | 80203 | WI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | WI |
| | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | WI |
| | Faith Partners Land Company, LLC | 4772 Tara Ct. | West Bloomfield | MI | 48323 | WI |
| | WYDJ ORI Investments I, LLC | P.O. Box 460868 | Denver | CO | 80246 | ORRI |
| | WYDJ Energy LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | ROW |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Wyoming Bank & Trust | 5827 Yellowstone Road | Cheyenne | WY | 82009 | MTG |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| T13N - R63W | Sharon E. Hayes Revocable Trust | 18821 Freemont Avenue North | Shoreline | WA | 98133 | SI / MI |
| Sec. 27: All | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Acoma Energy, LLC | 3801 E. Florida Avenue, Suite 508 | Denver | CO | 80210 | MI |
| | Beauleo Minerals, LLC | 5 Brighton Way | Farmington | CT | 06032 | MI |
| | Beth and Ken Karmin Family Trust | 1555 Capri Drive | Pacific Palasades | CA | 90272 | MI |
| | Fossil Creek Land Company | P.O. Box 485 | Mustang | OK | 73064 | MI |
| | Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 | MI |
| | The Greg & Nancy Vance Family Limited Partnership c/o Production Gathering Company, LP | 8080 N. Central Expressway, Suite 1090 | Dallas | TX | 75206 | MI |
| | Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 | MI |
| | Hydrocarbon Minerals II, LLC | P.O. Box 2157 | Bridgeview | IL | 60455 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | John Scott Gibson and Judy A. Gibson | 16838 Morgan Road 10 | Fort Morgan | CO | 80701 | MI |
| | MA - Minerals LLC | P.O. Box 3759 | Manhattan Beach | CA | 90266 | MI |
| | HOG BG, LLC | P.O. Box 526412 | Salt Lake City | UT | 84152 | MI |
| | Max Exploration, LLC | P.O. Box 9287 | Salt Lake City | UT | 84109 | MI |
| | HK Oil & Gas, LLC | P.O. Box 95285 | South Jordan | UT | 84095 | MI |
| | CLH - Minerals, LLC | P.O. Box 3759 | Manhattan Beach | CA | 90266 | MI |
| | SunTrust Mortgage, Inc. | 901 Semmens Avenue | Richmond | VA | 23224 | MTG |
| | Clear Creek Resource Partners | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| T13N - R63W | The te Velde Family LLLP | 7619 Road 19 | Fort Lupton | CO | 80621 | SI |
| Sec. 28: All | Audie Hoke and Cherie R. Hoke | 2509 Crosstimbers Drive | College Station | TX | 77840 | MI |
| | Bold Resources, LLC | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | MAP2009-OK c/o MAP Royalty, Inc. | 101 North Robinson Avenue, Suite 1000 | Oklahoma City | OK | 73102 | MI |
| | Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 | MI |
| | Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 | MI |
| | Charles W. and Patty N. Brown, LLC | 6408 Outabounds Court | Oklahoma City | OK | 73116 | MI |
| | Kyle D Shutt, as Trustee of the Kianna Royalty Trust, a Revocable Trust dated 3/1/19933 | P.O. Box 20571 | Oklahoma City | OK | 73156 | MI |
| | The J. Christopher Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | The Michael L. Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Kaiser-Francis Mid-Continent Limited Partnership | P.O. Box 2280 | Tulsa | OK | 74101 | WI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 | WI |
| | Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 | WI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Enerquest Oil & Gas, L.L.C. | 12368 Market Drive | Oklahoma City | OK | 73114 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | WI |
| | Renegade Resources, LLC c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Simmons Bank | 3001 Brighton Boulevard, Suite 718 | Denver | CO | 80216 | MTG |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Farmers & Merchants Bank of Colby | P.O. Box 797 | Colby | KS | 67701 | MTG |
| T13N - R63W | Joseph and Allison Ward | 535 Road 143 | Carpenter | WY | 82054 | SI |
| Sec. 29: All | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Production Credit Association of the Midlands | P.O. Box J | Torrington | WY | 82240 | MTG |
| | First State Bank, Division of Glacier Bank, Torrington Branch | P.O. Box 1098 | Torrington | WY | 82240 | MTG |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| T13N - R63W<br>Sec. 30: E2E2 | Leonarda Oberwise, Trustee under the | 484 Road 143 | Carpenter | WY | 82054 | SI / MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | The Mountain States Telephone and Telegraph Company | 931 14th Street | Denver | CO | 80202 | ROW |
| T13N - R63W<br>Sec. 30: W2E2 | Michael L. Oberwise | 3656 Red Baron Drive | Colorado Springs | CO | 80911 | SI / MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Norwest Bank Colorado, NA | 1740 Broadway | Denver | CO | 80274 | MTG |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T13N - R63W<br>Sec. 30: Lots 1, 2, E2NW | Marion O. Reeder, Trustee of the | 4100 Road 205 | Carpenter | WY | 82054 | SI |
| | Grayrock Minerals, LLC | 5950 Cedar Springs Road, Suite | Dallas | TX | 75235 | MI |
| | WYOCO Royalty Partners, LLC, a | 410 17th Street, Suite 1150 | Denver | CO | 80202 | MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Cheyenne Light, Fuel and Power | 1301 W. 24th Street | Cheyenne | WY | 82001 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| T13N - R63W<br>Sec. 30: Lots 3, 4, E2SW | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | WI |
| | WYDJ Energy LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | WI / ORRI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | WI / ORRI |
| | Faith Partners Land Company, LLC | 4772 Tara Ct. | West Bloomfield | MI | 48323 | WI / ORRI |
| | LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 | ORRI |
| | WYDJ Investments I LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | WYDJ ORI Investments I, LLC | P.O. Box 460868 | Denver | CO | 80246 | ORRI |
| | Diana K. Acheson and Fred L Acheson, Co-Trustees of he Fred L. Acheson and Diana K. Acheson Joint Revocable Trust U/A dated 10-16-2015 | P.O. Box 220 | Hillsdale | WY | 82060 | SI / MI |
| | Jill Jahn, aka Jill Tower aka Jill F. | P.O. Box 156 | Fishtail | MT | 59222 | MI |
| | Keith Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 | MI |
| | ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 | MI |
| | Cox Minerals LLC | P.O. Box 2015 | Billings | MT | 59103 | MI |
| | Janice Ann Taylor aka Jan Taylor aka Janice A. Taylor | 636 E. Magnesium Rd. Apt C-111 | Spokane | WA | 99208 | MI |
| | Ross M. Taylor | 34752 Bachelor Flat Road | St. Helens | OR | 97051 | MI |
| | Kimberly T. Dunn | 2631 W. Dell Drive | Spokane | WA | 99208 | MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | Laramie Operating LLC, a Colorado limited liability company | 1120 Lincoln Street, Suite 1605 | Denver | CO | 80203 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T13N - R63W<br>Sec. 31: E2 | The Gordon Malm Revocable Trust | P.O. Box 55 | Albin | WY | 82050 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 | MTG |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Pine Chalet Properties, LLC | 4022 E. 9th Street | Cheyenne | WY | 82001 | ROW |
| T13N - R63W<br>Sec. 31: Lots 1, 2, 3, 4, E2W2 | Pine Chalet Properties, LLC | 4022 E. 9th Street | Cheyenne | WY | 82001 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 | MTG |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | The Gordon Malm Revocable Trust dated 02-20-1998 | P.O. Box 55 | Albin | WY | 82050 | ROW |
| T13N - R63W<br>Sec. 32: All | Pine Chalet Properties, LLC | 4022 E. 9th Street | Cheyenne | WY | 82001 | SI |
| | Gordon Malm Revocable Trust | P.O. Box 55 | Albin | WY | 82050 | SI |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | Fanny L. Malm, Trustee of the Gordon Malm Revocable Trust dated | 6360 State Highway 216 | Albin | WY | 82050 | MI |
| | Henry Earl and Margaret D. Montgomery | 4022 E. 9th Street | Cheyenne | WY | 820041 | MI |
| | Malm Ranch Company | 6360 State Highway 216 | Albin | WY | 82050 | MI |
| | Red Harlan Royalties, LTD. | P.O. Box 670766 | Dallas | TX | 75367 | MI |
| | Water Oaks Capital Minerals, LLC | 2101 Cedar Springs, Suite 1600 | Dallas | TX | 75201 | MI |
| | Rearden Minerals, LLC | 5914 W. Courtyard Drive | Austin | TX | 78730 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | Basin Electric Power Cooperative | 1717 E. Interstate Avenue | Bismarck | ND | 58503 | ROW |
| | Clear Creek Resource Partners | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U.S. Bank Trust Company, N.A. | 425 Walnut Street, 6th Floor | Cincinnati | OH | 45202 | MTG |
| | Wells Fargo Bank , N.A. | P.O. Box 11701 | Newark | NJ | 07101- | MTG |
| T13N - R63W<br>Sec. 33: All | The te Velde Family LLLP | 7619 Road 19 | Fort Lupton | CO | 80621 | SI |
| | Gordon Malm Revocable Trust | P.O. Box 55 | Albin | WY | 82050 | SI / MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko Land Corp., a Nebraska corporation, formerly Union Pacific Land Resources Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | J. Christopher Dykes, as Trustee of The J. Christopher Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Robert P. Dykes, as Trustee of The Robert P. Dykes Revocable Trust, dated 10/14/2011 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 | MI |
| | Fossil Creek Land Company | P.O. Box 485 | Mustang | OK | 73064 | MI |
| | Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 | MI |
| | Audie Hoke and Cherie R. Hoke | 2509 Crosstimbers Drive | College Station | TX | 77840 | MI |
| | The Ridge, LLC | 392 County Road 145 | Carpenter | WY | 82054 | MI |
| | Bold Resources, LLC | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Deborah L. Shepardson | 811 Heather Lane | Montrose | CO | 81401 | MI |
| | Charles W. and Patty N. Brown, LLC | 6408 Outabounds Court | Oklahoma City | OK | 73116 | MI |
| | MAP2009-OK c/o MAP Royalty, Inc. | 101 North Robinson Avenue, Suite 1000 | Oklahoma City | OK | 73102 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Kaiser-Francis Mid-Continent Limited Partnership | P.O. Box 2280 | Tulsa | OK | 74101 | WI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 | WI |
| | Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 | WI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Enerquest Oil & Gas, L.L.C. | 12368 Market Drive | Oklahoma City | OK | 73114 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Renegade Resources, LLC c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Simmons Bank | 3001 Brighton Boulevard, Suite 718 | Denver | CO | 80216 | MTG |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Farmers & Merchants Bank of Colby | P.O. Box 797 | Colby | KS | 67701 | MTG |
| | Farm Service Agency | 1560 B-Johnston Street | Wheatland | WY | 82201 | MTG |
| | American AgCredit, FLCA | 45065 W. 29th Street | Greeley | CO | 80634-8763 | MTG |
| T13N - R63W<br>Sec. 34: All | Robert M. Roof, Jr. and Sheala Roof | 390 Road 146 | Carpenter | WY | 82054 | SI / MI |
| | Farmer Family Trust | 5135 Syracuse Road | Cheyenne | WY | 82009 | SI |
| | John L. and Janet I. Farmer | 5135 Syracuse Road | Cheyenne | WY | 82009 | SI / MI |
| | Linda D. and Stephen G. Nelson | 5200 N.E. 69th Terrace | Kansas City | MO | 64119 | MI |
| | Francis Edward Oline Intervivos Trust, dated 11/5/2003 | 1522 Copperville Road | Cheyenne | WY | 82001 | MI |
| | Donald A. and Stacy L. Edgar | 17892 Bagby Road | Green Ridge | MO | 65332 | MI |
| | James E. Edgar aka James Eugene Edgar | 1906 Euclid | Wichita | KS | 67213 | MI |
| | Charles J. and Caroline J. Edgar | 1225 SE 260th Road | Clinton | MO | 64735 | MI |
| | Ruth Enfield Edgar | Unknown Address | | | | MI |
| | Alice E. and Gary W. Jones | 4512 Pool Road | Joplin | MO | 64801 | MI |
| | Roseshell A. Ward | Unknown Address | | | | MI |
| | Cassandra J. Ward | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Charlotte L. Sharp | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Manuel Blanco, IIII | Unknown Address | | | | MI |
| | WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Ruth M. and John P. Rome | 6516 Hedge Lane Terrace, Apt. # 106 | Shawnee | KS | 66226 | MI |
| | Elah and Margaret B. Helper | 6009 East Boise Street | Mesa | AZ | 85205 | MI |
| | Lincoln Energy Partners, LLC | P.O. Box 6975 | Denver | CO | 80206 | MI |
| | Platte Valley Energy, LLC | 852 Broadway, Suite 300 | Denver | CO | 80203 | MI |
| | AK Resources, LLC | P.O. Box 6975 | Denver | CO | 80206 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| T13N - R63W<br>Sec. 35: All | Robert M. Roof, Jr. and Sheala Roof | 390 Road 146 | Carpenter | WY | 82054 | SI |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | SI / ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | SI / ROW |
| | Crow Creek Cattle, LLC | 7678 Road 17 | Fort Lupton | CO | 80621 | SI |
| | Robert M. Roof, Jr. and Sheala Roof | 390 Road 146 | Carpenter | WY | 82054 | SI / MI |
| | Roy F. and Barbara J. Young | 4820 Road 214 | Burns | WY | 82053 | SI / MI |
| | Elah and Margaret B. Helper | 6009 East Boise Street | Mesa | AZ | 85205 | MI |
| | Platte River Energy, LLC | 852 Broadway, Suite 300 | Denver | CO | 80203 | MI |
| | WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Linda D. and Stephen G. Nelson | 5200 N.E. 69th Terrace | Kansas City | MO | 64119 | MI |
| | Alice E. and Gary W. Jones | 4512 Pool Road | Joplin | MO | 64801 | MI |
| | Roseshell A. Ward | Unknown Address | | | | MI |
| | Cassandra J. Ward | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Charlotte L. Sharp | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Manuel Blanco, IIII | Unknown Address | | | | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Charles J. and Caroline J. Edgar | 1225 SE 260th Road | Clinton | MO | 64735 | MI |
| | Donald A. and Stacy L. Edgar | 17892 Bagby Road | Green Ridge | MO | 65332 | MI |
| | James E. Edgar aka James Eugene Edgar | 1906 Euclid | Wichita | KS | 67213 | MI |
| | Loyd Farms, GP, James A. and Lonna J. Loyd | 66732 WCR 136 & 87 | Hereford | CO | 80732 | MI |
| | Ellen Crowley, Attorney In Fact for Leota Russel aka Leota M. Russell | P.O. Box 287 | Cheyenne | WY | 82003 | MI |
| | Abraham Black, Trustee of the Black Family Trust, 10/13/1997 | Unknown Address | | | | MI |
| | Deborah A. Campbell aka Debra A. Campbell | P.O. Box 596 | Martin | SD | 57551 | MI |
| | Alice E. and Gary W. Jones | 4512 Pool Road | Joplin | MO | 64801 | MI |
| | Ruth M. and John P. Rome | 6516 Hedge Lane Terrace, Apt. # 106 | Shawnee | KS | 66226 | MI |
| | Thomas W. Stagg | 1309 Ironwood Street | Boulder City | NV | 89004 | MI |
| | Mark R. Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | David F. Stagg | 9609 239th Street North | Port Byron | IL | 61275 | MI |
| | Elenor Stagg King | P.O. Box 3033 | Clinton | IA | 52732 | MI |
| | AK Resources, LLC | P.O. Box 6975 | Denver | CO | 80206 | MI |
| | Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 | MI |
| | James David and Kathleen Edna Young | Unknown Address | | | | MI |
| | Lincoln Energy Partners, LLC | P.O. Box 6975 | Denver | CO | 80206 | MI |
| | Anadarko Land Corp., a Nebraska corporation, formerly Union Pacific Land Resources Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Ruth Enfield Edgar | Unknown Address | | | | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Gene G. Purdy | Unknown Address | | | | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| T13N-R63W<br>Sec. 36: All | Ronald D. and D Anna L. Catterson | 384 Road 148 | Carpenter | WY | 82054 | SI |
| | Everett Rhodes | P.O. Box 447 | Carpenter | WY | 82054 | SI |
| | Cody L. Smith | 291 Road 152 | Carpenter | WY | 82054 | SI |
| | Jason W. Smith and Lisa J. Smith | P.O. Box 401 | Carpenter | WY | 82054 | SI / MI |
| | Ryan F. and Vicki M. Nelson | 2070 Franklin Street | Laramie | WY | 82070 | SI / MI |
| | Dale R. and Sharon Martin | 324 County Road 148 | Carpenter | WY | 82054 | MI |
| | Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 | MI |
| | Mark R. Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Edith E. Lang, Trustee, or her successors in trust, of the Edith E. Lang Living Trust, dated 4/5/1999 | P.O. Box 37, Route 1 | Carpenter | WY | 82054 | MI |
| | Gary P. and Norma Jean Smith | P.O. Box 365 | Carpenter | WY | 82054 | MI |
| | Randy J. Peters | Unknown Address | | | | MI |
| | Joseph G. Lynch | P.O. Box 4308 | Williston | ND | 58802 | MI |
| | Eric Wilt | P.O. Box 1473 | Williston | ND | 58802 | MI |
| | Dale A. Swanson | 339 Indian Paintbrush Drive | Golden | CO | 80401 | MI |
| | David G. Majewski | 11823 South Maxwell Hill Road | Littleton | CO | 80127 | MI |
| | Dennis W. Yockim | 8765 Greensborough Place | Littleton | CO | 80129 | MI |
| | Cody L. Smith | 291 Road 152 | Carpenter | WY | 82054 | MI |
| | Loyd Farms, GP, James A. and Lonna J. Loyd | 66732 WCR 136 & 87 | Hereford | CO | 80732 | MI |
| | OKSA Minerals, LP | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Fredericksburg Royalty, Ltd | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Curzon Management, LLC | 408 Canterbury Hill | San Antonio | TX | 78209 | MI |
| | BCP Energy, LLC | P.O. Box 472059 | Fort Worth | TX | 76147 | MI |
| | Wake Energy, LLC | P.O. Box 5074 | Edmond | OK | 73083 | MI |
| | Swanson Production Company | 339 Indian Paintbrush Drive | Golden | CO | 80401 | MI |
| | Lynx Oil Company | 9736 West Swarthmore Drive | Littleton | CO | 80123 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | Hydrocarbon Minerals II, LLC | P.O. Box 2157 | Bridgeview | IL | 60455 | MI |
| | Oneonta Resources, LLC | 5228 Lonetree Drive | Loveland | CO | 80537 | MI |
| | Arrow Energy, LLC | 809 W. 3rd Street | McCook | NE | 69001 | MI |
| | LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |

# APPENDIX L—GEOCHEMICAL REPORT

## Introduction

The mineral-brine-$CO_2$ interactions that occur during $CO_2$ sequestration lead to the alteration of host rock and eventual equilibrium in the mineral-brine-$CO_2$ system. Chemical modeling and laboratory experiments show that these reactions and eventual equilibria are driven by the specific mineralogy of the target formation, the composition of the brine, the acidity of the $CO_2$-brine mixture and the pressure and temperature in the subsurface. This chapter covers the modeling of the mineral-brine-$CO_2$ system across the mineralogical facies associations present for the subject site.

## Methods

Simplified, batch kinetic simulation experiments (models) were created for each facies present at the subject location. The models use phase thermodynamic data in the PHREEQC Lawrence Livermore National Laboratory Database and reaction kinetics from Palandri and Kharaka (2004) to model the $CO_2$-brine-rock interactions. Each simulation experiment is isothermal, with the temperature set to match the subject location and depth. The pressure for each simulation experiment is also static and set to match the subject location and depth. The thermodynamic model is based on local equilibrium for the minerals and ions in an aqueous phase. The kinetic calculations assume that abundant $CO_2$ is supplied to the system during the simulation and that any consumed molecule of $CO_2$ is replaced. These simplifying assumptions align with the reality of the physical system in that continuous injection allows for abundant gas supply to the system.

## Brine Geochemistry

The brine composition used for the simulations is derived from three flash water samples acquired during the Juniper M-1 testing program. In the testing process, the well was perforated from 9,165 ft to 9,171 ft, within the Lyons Formation interval. The water sampling tool was then placed at three depths while the well was pumped resulting in three samples from the injection target interval. The anion composition of each sample was analyzed using ion chromatography while cation compositions were analyzed using inductively coupled plasma optical emission spectrometry. The pH and alkalinity were measured using ASTM D1293 and ASTM D1125 respectively. A subset of anions and cations relevant to mineral-brine-$CO_2$ interactions are summarized for each sample in Table 1. The available analytical values were averaged for each mineral facies to create a composite brine composition that was used in each model (Table 2).

Table L.1—Composition of water samples.

| Formation | Depth | pH | TDS | $HCO_3$ | $SO_4$ | Cl | I | Ca | Fe | K | Mg | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lyons | 9,081.92 | 6.36 | 216,280 | 134 | 3,515 | 128,666 | 126 | 495 | 18 | 2,529 | 904 | 82,175 |
| Lyons | 9,096.26 | 6.43 | 216,280 | 160 | 3,610 | 128,581 | 0 | 508 | 18 | 2,426 | 874 | 80,734 |
| Lyons | 9,066.67 | 6.45 | 216,280 | 130 | 3,607 | 128,976 | 127 | 500 | 18 | 2,564 | 948 | 79,384 |

Table L.2—Average brine composition by mineral facies.

| Mineral Facies | Facies Name | Modeled Depth | Stratigraphic Interval | pH | TDS | $HCO_3$ | $SO_4$ | Cl | I | Ca | Fe | K | Mg | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Facies 0 | Sandstone | 9,153 | Lyons | 6.40 | 216,280 | 147 | 3,577 | 128,741 | 84 | 501 | 18 | 2,506 | 909 | 80,764 |
| Facies 1 | Mudstone | 8,727 | Chugwater | 6.40 | 216,280 | 147 | 3,577 | 128,741 | 84 | 501 | 18 | 2,506 | 909 | 80,764 |
| Facies 1 | Mudstone | 9,187 | Satanka | 6.40 | 216,280 | 147 | 3,577 | 128,741 | 84 | 501 | 18 | 2,506 | 909 | 80,764 |
| Facies 2 | Carbonate and Dolostone | 9,119 | Goose Egg | 6.40 | 216,280 | 147 | 3,577 | 128,741 | 84 | 501 | 18 | 2,506 | 909 | 80,764 |

**Mineral Geochemistry**

Despite the well understood nature of the stratigraphy in the vicinity of the subject site, published X-Ray Diffraction (XRD) data across the study formations are scarce. There is, however, good well-log control including numerous log suites that enabled the creation of a multi-mineral petrophysical model. The values from this model were analyzed using K-nearest neighbor (KNN) clustering in order to determine the number of mineralogical facies present.

An elbow plot and a silhouette plot, as shown in Figure 1, are used to select the number of clusters to be used in the KNN process. In the Elbow Plot, the number of clusters present is indicated by a flattening in the distortion value (y-axis). In the silhouette plot, the number of clusters present is indicated by a maximum in the average value (y-axis). In the case of this dataset, the number of clusters indicated by both methods is three. The mineralogical facies clusters can be plotted against a matrix of the mineralogical volume curves, this is called a small multiples plot and shows the veracity of the clustering. This plot can be viewed in Figure 2.

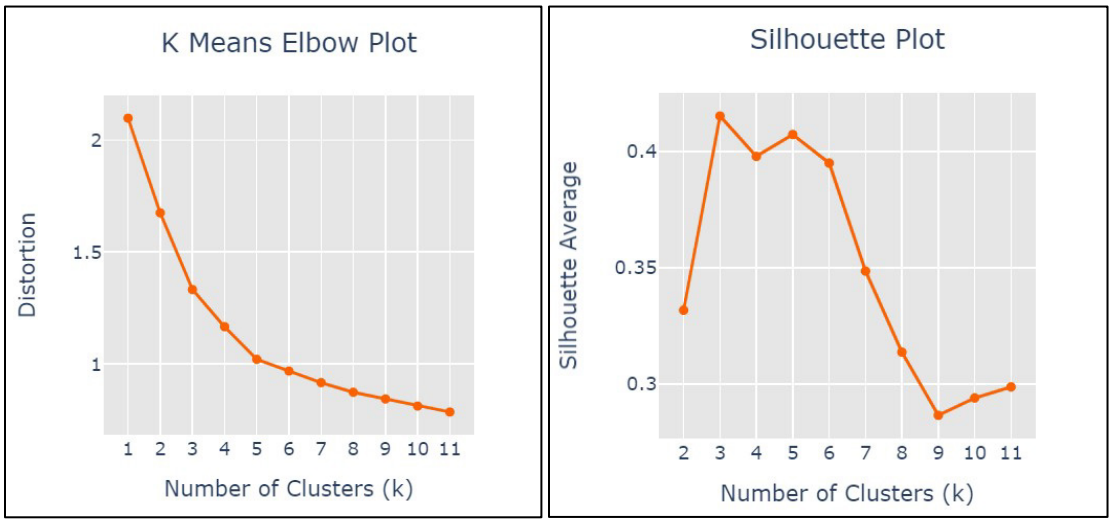



Figure L.1—Elbow and silhouette plots for the multi-mineral model dataset in the Juniper M-1 well are shown.

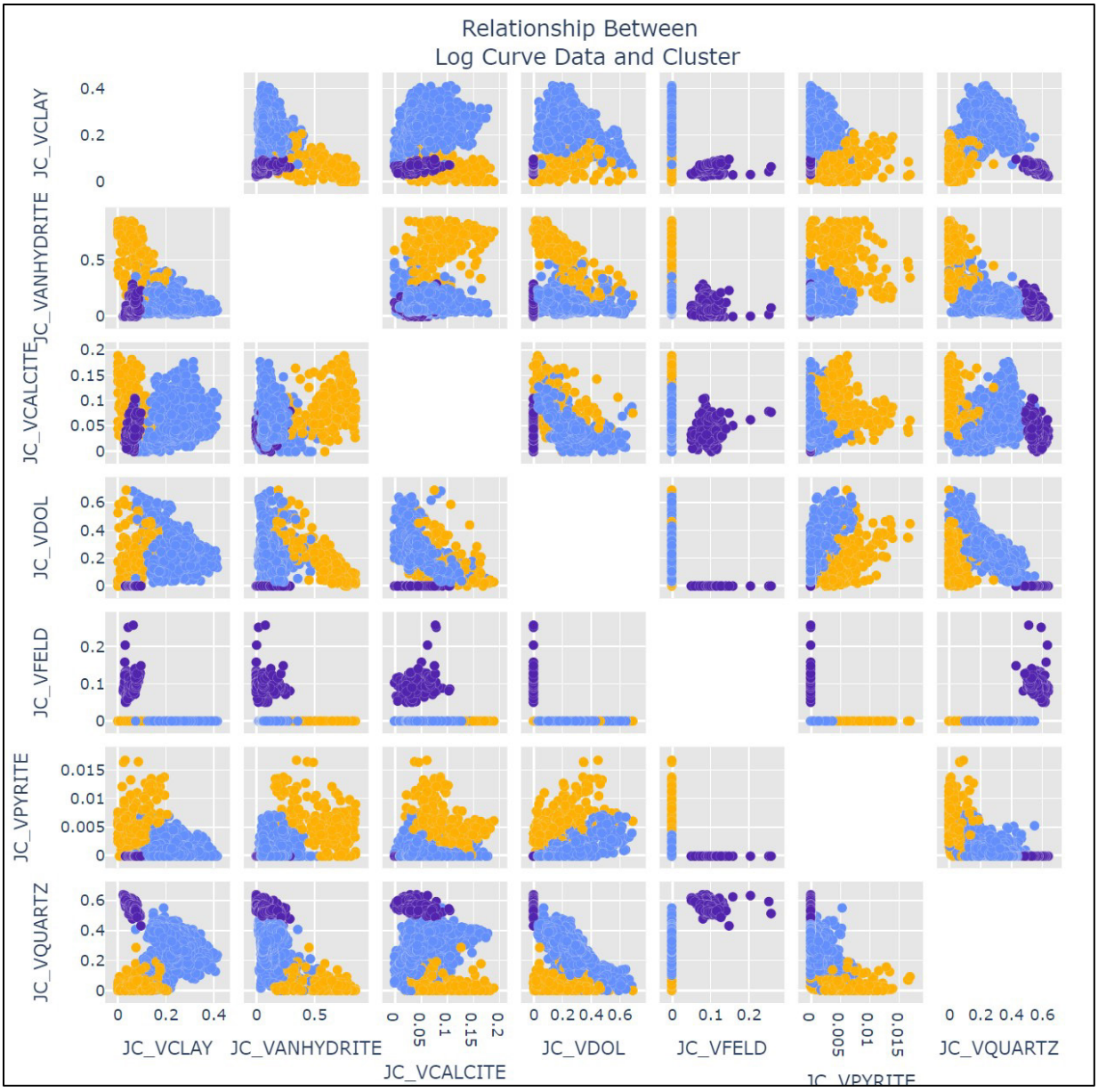



Figure L.2—Relationship between mineral facies (KNN clusters) and the multi-mineral petrophysical model compositions in the Juniper M-1

Data from 24 core plug samples obtained during the Juniper M-1 testing program, across the injection and seal intervals, were used in this analysis. Those samples were used in conjunction with XRF data to calibrate the multi-mineral model for the Juniper M-1 well and to create an LAS file. This LAS file was analyzed and broken into four mineral facies specified by the KNN analysis. Average mineralogic compositions were calculated for each of the four mineral facies and used to represent the injection and seal zone mineralogy for batch modeling.

Mineral compositions used in the models are shown in Table 3. Facies 1, a silica rich mudstone has two end member compositions, one for the Chugwater Formation and a second for the Satanka Formation. The Lyons Formation injection zone endmember (Facies 0) is a quartz-rich facies with feldspar, clay, and anhydrite. The Chugwater endmember, Facies 1, is a mudstone

made up of near equal parts clay, quartz, and carbonate. The Satanka end member of Facies 1 is a quartz-rich mudstone with carbonate and clay. The Goose Egg end member (Facies 2) is an anhydrite rich, carbonate mudstone with quartz and clay.

Table L.3—Mineral composition of facies clusters.

| Mineral Facies | Facies Name | Modeled Depth | Stratigraphic Interval | Quartz | Calcite | Plag (albite) | K-spar | Smectite | Illite | Anhydrite |
|---|---|---|---|---|---|---|---|---|---|---|
| Facies 0 | Sandstone | 9,153 | Lyons | 76.6 | 0 | 4 | 6.3 | 0 | 1.9 | 9.6 |
| Facies 1 | Mudstone | 8,727 | Chugwater | 34 | 30 | 0 | 0 | 3.2 | 28.8 | 0 |
| Facies 1 | Mudstone | 9,187 | Satanka | 42 | 25 | 0 | 0 | 2.7 | 24.3 | 0 |
| Facies 2 | Carbonate | 9,119 | Goose Egg | 13 | 46 | 0 | 0 | 1.2 | 10.8 | 27 |

The depth plot of the mineralogical facies assemblages for the Juniper M-1 well is shown in Figure 3. The eighth track shows the results of the KNN clustering with each 0.5-foot interval colored to match the cluster to which it is assigned.

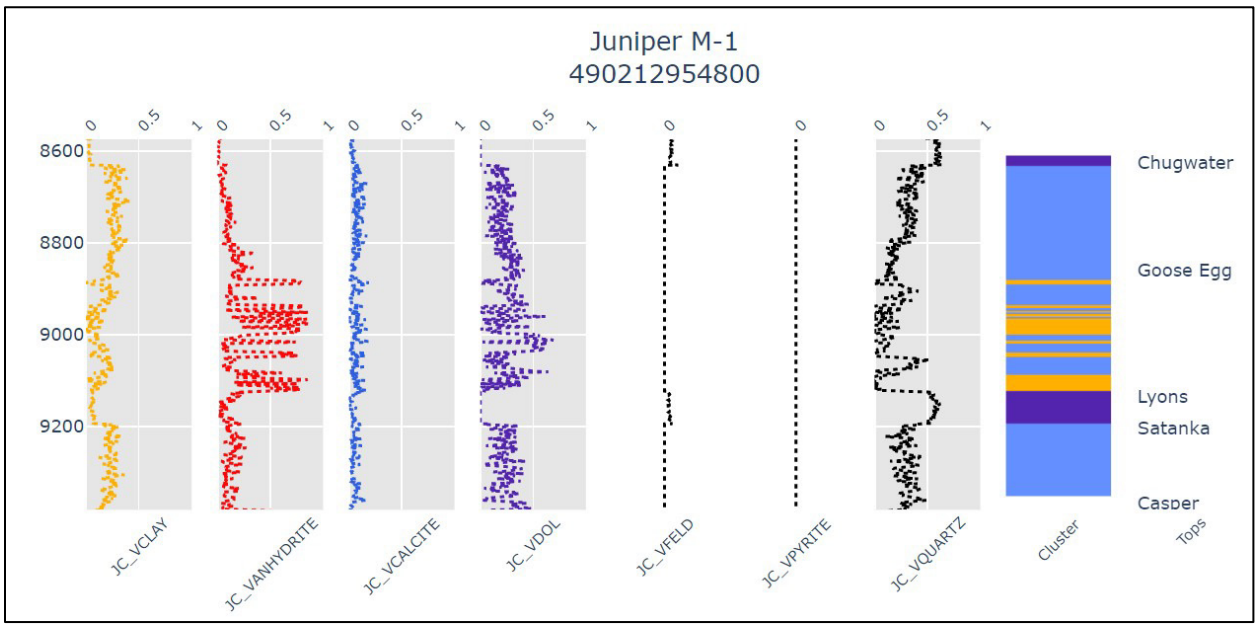



Figure L.3—Depth plot of the mineralogical facies assemblages for the Juniper M-1 well. Track eight shows the mineralogical facies to which each depth interval is assigned.

## Models

A total of four geochemical models were created using the three mineral facies associations calculated from the well log analysis. The Chugwater and Lyons formation models were evaluated at their average depth. The Goose Egg model was evaluated at the Goose Egg-Lyons interface. The Satanka model was evaluated at the Lyons-Satanka interface.

The processes expected in the subsurface were modeled as a product of thermodynamic equilibrium and kinetic reactions using PHREEQC. The models were created as simplified, 1-D batch models that occur at pressure and temperatures dictated by their stratigraphic position. The models assume a pressure gradient of 0.30 psi/ft and a thermal gradient of 1.34°F/100 ft with a mean annual surface temperature of 75°F. The injected volume of $CO_2$ was assumed to fill the pore spaces.

## Results

Across all the models, the results show that quartz and dolomite precipitate while other species have complex reactions dependent on the initial composition. Reactions begin to occur after a few seconds of contact and accelerate through the first several hundred years. From 1,000 to 10,000 years the reactions reach equilibrium (Figure 4).

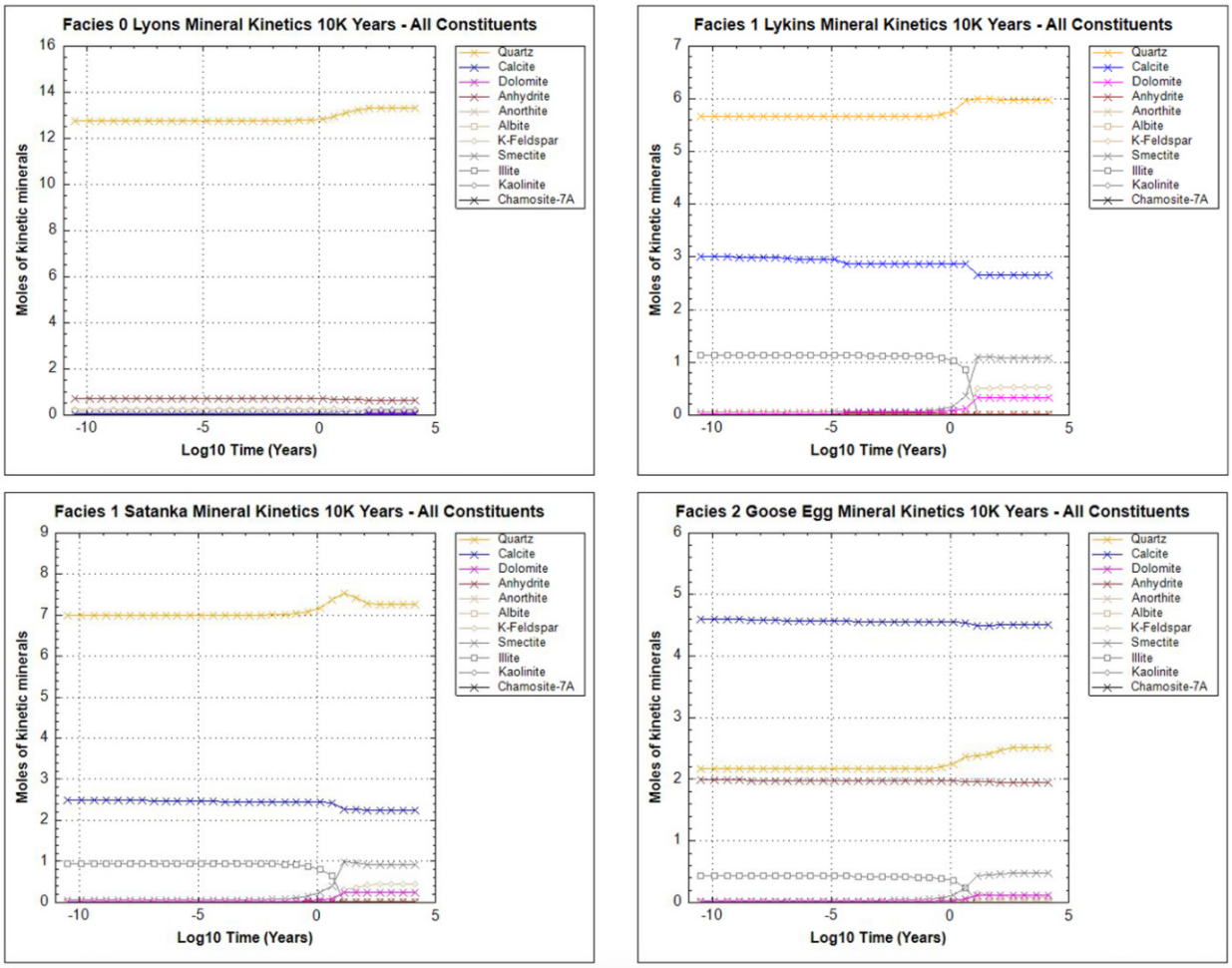
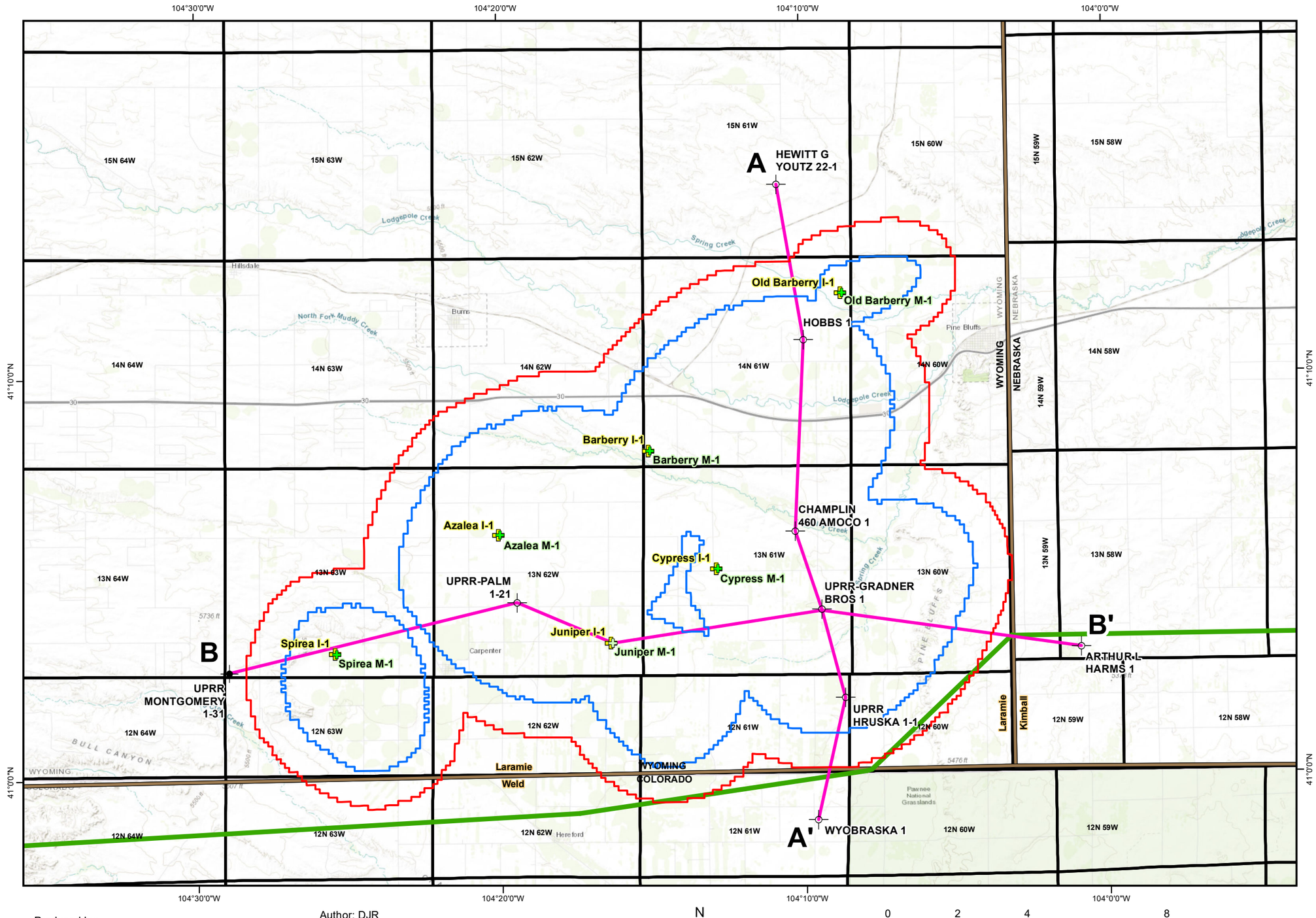



Figure L.4—Batch model results by facies. The x-axis is log 10 time in seconds. The reaction time spans from 0.001 seconds to 10,000 years.

The Chugwater and Satanka mudstone confining intervals show precipitation of quartz and dissolution of calcite (the principal mineral constituents) along with dissolution of illite and precipitation of smectite and feldspar in the minor constituents. The Goose Egg confining interval shows precipitation quartz and mild dissolution of anhydrite (the principal components) along with dissolution of illite and precipitation of smectite in the minor components. In the Lyons injection interval the largest constituent (quartz) shows net precipitation while in the minor constituents anhydrite, k-feldspar, plagioclase (albite), and illite dissolve while kaolinite and calcite precipitate.

Across all the models, the simulations show a net mineral change of less than 8%.

Mild net precipitation in the injection facies will lead to a small amount of porosity reduction over time especially at the upper confining zone-injection zone interface. Net precipitation and alteration of illite to smectite at the Goose Egg-Lyons interface should support seal capacity over the course of injection. Net precipitation and conversion of illite to smectite should support seal capacity over time in the Chugwater and Satanka confining intervals.




## Project Wells

- Proposed Injection Well
- Proposed Monitoring Well
- Monitoring Well
- AoR - End of Monitoring
- AoR Plus 1 Mile Radius
- USDW Cross Section Line
- Trailblazer Pipeline*
- US State Boundary
- PLSS Townships

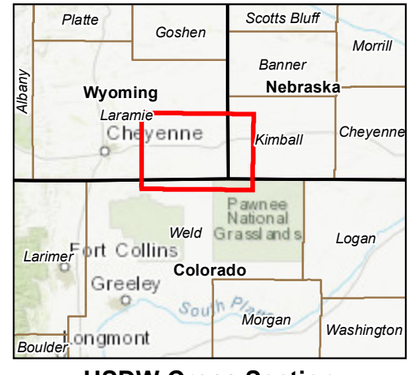
## USDW Cross-Section Wells

### Well Status

- Dry Hole
- Plugged & Abandoned Oil & Gas

* Source: Well SHL Data - DrillingInfo (2023)
* Source: Trailblazer Pipeline - Energy Information Administration (EIA)

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community




## USDW Cross Section Locator Map

**Tallgrass High Plains Carbon Storage, LLC**
**Laramie County, WY**

Produced by:
Numeric Solutions LLC
Geoinformation Management
1536 Eastman Avenue, Suite D
Ventura, CA 93103
805-794-5011 | www.numericsolutions.com

Author: DJR
Date: 11/15/2023
Document Name: 3.15_USDW_Cross_Section_Locator_Map

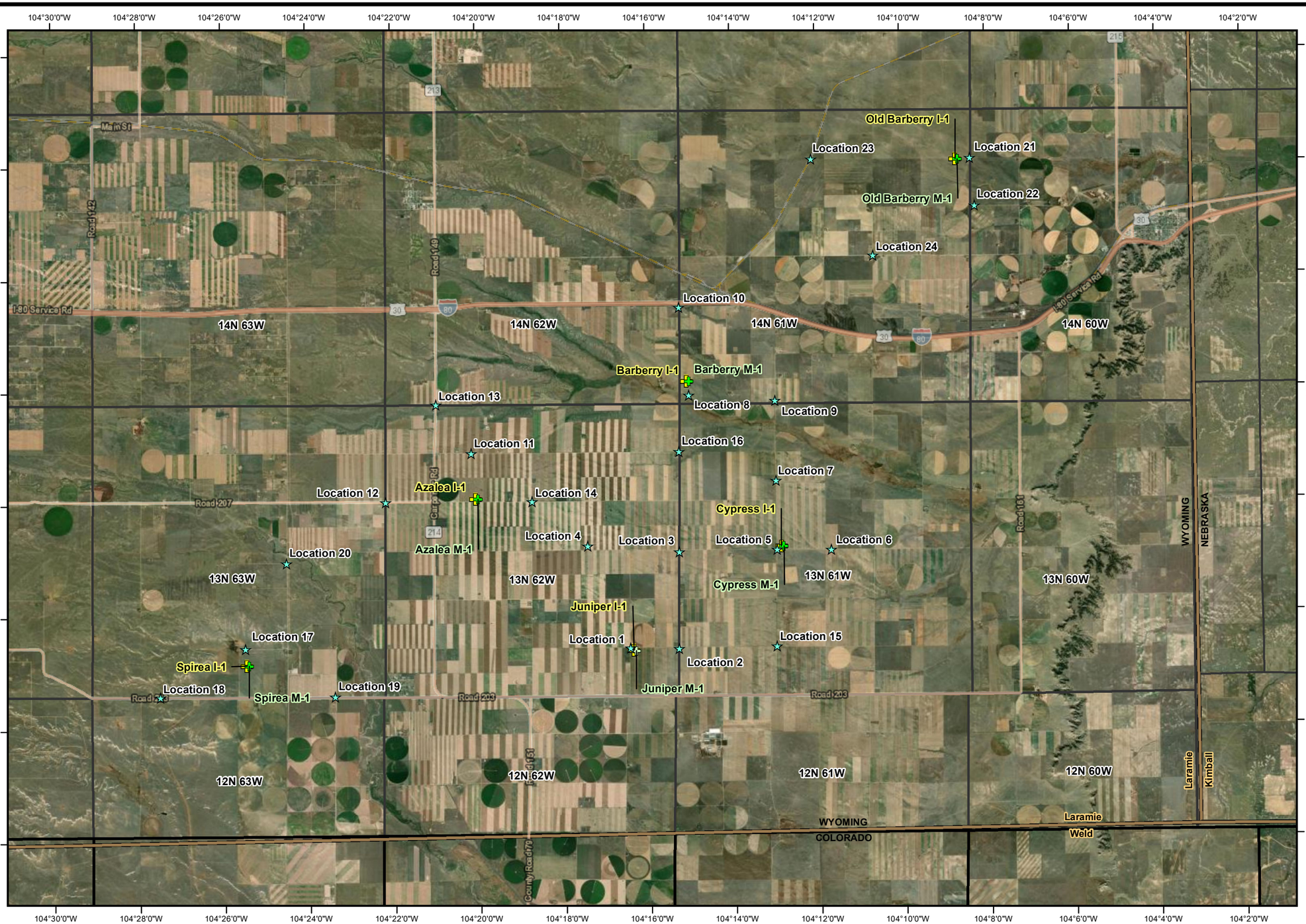
Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
Projection: Transverse Mercator
Datum: North American 1983

N

0 2 4 8 Miles

0 15,000 30,000 60,000 Feet

1:180,000




Air Monitoring Locations

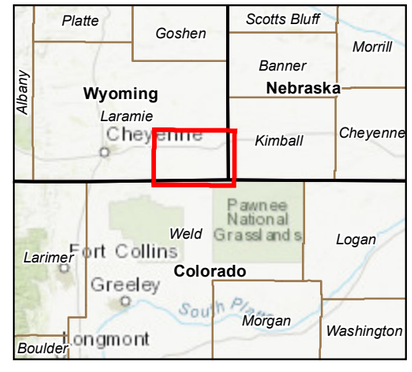
US State Boundary

PLSS Townships

## Project Wells

- Proposed Injection Well
- Proposed Monitoring Well
- Monitoring Well

Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community




Produced by:

Numeric Solutions LLC
Geoinformation Management

1536 Eastman Avenue, Suite D
Ventura, CA 93103
805-794-5011 | www.numericsolutions.com

Author: DJR

Date: 11/15/2023

Document Name: 4.3_Air_Monitoring_Locations

Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
Projection: Transverse Mercator
Datum: North American 1983

N

0 1.5 3 6 Miles

0 5,000 10,000 20,000 Feet

1:130,000

# Air Monitoring Locations

## Tallgrass High Plains Carbon Storage, LLC
## Laramie County, WY

## ATTACHMENT A-2: Public Notice Affidavit for Application Submittal and Landowner Notification

W.S. 35-11-313(ii)(N): Proof of notice to surface owners, mineral claimants, mineral owners, lessees and other owners of record of subsurface interests as to the contents of such notice. Notice requirements shall at a minimum require:
(I) The publishing of notice of the application in a newspaper of general circulation in each county of the proposed operation at weekly intervals for four (4) consecutive weeks;
(II) A copy of the notice shall also be mailed to all surface owners, mineral claimants, mineral owners, lessees and other owners of record of subsurface interests which are located within one (1) mile of the proposed boundary of the geologic sequestration site.

This Attachment is specific to private and commercial landowners.

- December 27, 2023

| **Concerning the Permit Application for:** | **Project Location:** |
|---|---|
| Eastern Wyoming Sequestration Hub Facility; ID No: WYS-021-00155, UIC Class VI Permit Application No. 2023-041 for Tallgrass High Plains Carbon Storage, LLC pursuant to Wyoming Statute (35-11-313)(f)(ii)(N) | **Township 13 North, Range 63 West, 6th P.M.**<br>Section 34: SWNW<br>Laramie County, Wyoming |

# AFFIDAVIT OF MAILING AND NOTICE

STATE OF WYOMING }
} §
COUNTY OF LARAMIE }

Cody Wagoner, of lawful age, and being first duly sworn upon his oath, states and declares:

That he is the Director of Land for Tallgrass High Plains Carbon Storage, LLC;

That on the 4th day of January 2024, he caused a copy of the attached *Notice Letter*, referenced on Exhibit "A" to be deposited in the United States Mail, by postage prepaid certified mail, return receipt requested, at the address listed for each such person on Exhibit "B";

That on the 8th day of January 2024, he also caused a *Notice of Geological Sequestration Project*, referenced on Exhibit "C" to be published weekly for four (4) consecutive weeks in the Wyoming Tribune Eagle and Laramie Boomerang newspapers;

Affiant further hereby certifies and affirms that on the 10th day of January 2024, he caused a true and correct copy of the herein referenced documents to be sent via electronic mail, addressed as follows:

Wyoming Department of Environmental Quality
Water Quality Division
Attn: Lily Barkau, Groundwater, Section Manager
lily.barkau@wyo.gov

Cody Wagoner, Affiant

Subscribed and sworn to before me by Cody Wagoner, Director of Land for Tallgrass High Plains Carbon Storage, LLC on this 10th day of January, 2024.

Witness my hand and official seal.

TIERCE WEAVER
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 20224027869
MY COMMISSION EXPIRES JULY 18, 2026

Notary Public

# Exhibit "A"

January 10, 2024

Address of surface owners, mineral claimants, mineral owners, lessees and other owners of record of subsurface interest

RE: Carbon Sequestration Project: Eastern Wyoming Sequestration Hub
Facility ID No: WYS-021-00155, UIC Class VI Permit Application No. 2023-041
Laramie County, Wyoming

Dear OWNER:

Tallgrass High Plains Carbon Storage, LLC. has submitted a Carbon Sequestration Underground Injection Control Program permit application for a Class VI well to the Wyoming Department of Environmental Quality on December 21, 2023. The purpose of this notice is to inform you that the application has been submitted and you have been identified as a surface owner, mineral claimant, mineral owner, lessees, or other owner of record of subsurface interest within one (1) mile of the proposed boundary of the geologic sequestration site. We are required by Wyoming Statute (35-11-313(f)(ii)(N) to provide a copy of the notice to you for your reference. The project is located in the SW ¼ NW ¼ Section No. 34, Township 13N, Range 63W of the 6th Principal Meridian, Laramie County, Wyoming.

A copy of the permit application may be accessed at https://deq.wyoming.gov/water-quality/groundwater/uic/class-vi/. If you have questions regarding the permit application, please contact Lily Barkau, Groundwater Section Manager, Water Quality Division, Wyoming Department of Environmental Quality at 307-777-7072 or lily.barkau@wyo.gov.

Sincerely,

NAME
TITLE
COMPANY

cc: Lily Barkau, WDEQ/WQD (lily.barkau@wyo.gov)

| Exhibit "B" | | | | |
|---|---|---|---|---|
| **Organization** | **Address 1** | **City** | **Region** | **Postal Code** |
| 293Frog, LLC | 7551 Bocage Boulevard | Baton Rouge | LA | 70809 |
| 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 |
| Abby Jo Ragan | Unknown Address | | | |
| Abigail and Kevin Oblak | 5426 Sagebrush Avenue | Cheyenne | WY | 82009 |
| Abraham Black, Trustee of the Black Family Trust, 10/13/1997 | Unknown Address | | | |
| Abram Landis Derstine & Annette Marie Destine, HW, TBE | 215 County Road 148 | Carpenter | WY | 82054 |
| Acoma Energy, LLC | 3801 E. Florida Avenue, Suite 508 | Denver | CO | 80210 |
| Adrian Lynn Arp | P.O. Box 703 | Filer | ID | 83328 |
| Advanta IRA Trust, LLC FBO: Gale E. Christenson IRA xxx6601 | 1520 Royal Palm Square Boulevard #320 | Fort Myers | FL | 33919 |
| Advanta IRA Trust, LLC FBO: Mark K. Christenson IRA xxx6401 | 1520 Royal Palm Square Boulevard #320 | Fort Myers | FL | 33919 |
| AK Resources, LLC | P.O. Box 6975 | Denver | CO | 80206 |
| Albert E. Kranz and Michelle L. Kranz | 406 E. 3rd | Pine Bluffs | WY | 82082 |
| Albert Goodis and Barbara Buck, Individually | 111 Water Rock Circle | Wayneville | NC | 28786 |
| Albert H. Glassburn and Mary E. Glassburn, husband and wife | P.O. Box 755 | Jackson | WY | 83001 |
| Albert John Faris and Betty Lou Faris | P.O. Box 53 | Rock River | WY | 82083 |
| Alice E. and Gary W. Jones | 4512 Pool Road | Joplin | MO | 64801 |
| Alice G. Tower | 2434 Rancho Road | Billings | MT | 59102 |
| Alice Jones | Unknown Address | | | |
| Allen D. and April J. Kinnison | 274 Road 147 | Carpenter | WY | 82054 |
| Allen D. and April J. Kinnison | 274 Road 147 | Carpenter | WY | 82054 |
| Alton Dwyer | 6921 South West 178th Avenue | Southwest Ranches | FL | 33331 |
| Amanda Jo Miller- McClanahan | Unknown Address | | | |
| American Agcredit, FLCA | P.O. Box 1120 | Santa Rosa | CA | 95402 |
| American AgCredit, FLCA | 45065 W. 29th Street | Greeley | CO | 80634-8763 |
| American Shale Energy LLC | 2929 Buffalo Speedway Suite 2106 | Houston | TX | 77098 |
| Amy Christine Collins | P.O. Box 1356 | Stenenson | WA | 98648 |
| Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 |
| Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 |
| Anadarko Land Corp., a Nebraska corporation, formerly Union Pacific Land Resources Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 |
| Anadarko Oil & Gas 5, LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 |
| ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 |
| Andrew L. Peabody | P.O. Box 2120 | Natchez | MS | 39121 |
| Anita Ruth Johnson c/o Barbara Duggan | P.O. Box 35 | Hereford | CO | 80732 |
| Ann Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 |
| Anthony Haar and Sheralee Clark | 4765 Road 206 | Carpenter | WY | 82054 |
| Anthony LLC | 21 Dowd Court | Kimball | NE | 69145 |
| Apollo Operating, LLC | 1538 Wazee Street, Suite 200 | Denver | CO | 80202 |
| April Sims | 1991 CR 1 #A | McFadden | WY | 82083 |
| Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 |
| Ardith A. Cushing Revocable Trust dated October 17, 2023 | 1105 Beech Avenue | Pine Bluffs | WY | 82082 |
| Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 |
| Arnold and Jeanne Bautista | 94 Road 148 | Carpenter | WY | 82054 |
| Arrow Energy, LLC | 809 W. 3rd Street | McCook | NE | 69001 |
| Arthur G. Rice | 5228 US Hwy 421 N | Wilmington | NC | 28401 |
| Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 |
| AT&T Mobility Corporation | 1025 Lenox Park Blvd. NE 3rd Floor | Atlanta | GA | 30319 |
| Audie Hoke and Cherie R. Hoke | 2509 Crosstimbers Drive | College Station | TX | 77840 |
| B. Frank Brady | Unknown Address | | | |
| Bambi Fernandez 2004 Trust | 1637 Edmonton Avenue | Sunnyvale | CA | 94087 |
| Bank of America | 101 South Tryon Street | Charlotte | NC | 28255 |
| Bank of Oklahoma, N.A., as Agent for U.S. Bank, N.A., Trustee of the T.E. McClintock T/U/W fbo Mary M. Swift | P.O. Box 3499 | Tulsa | OK | 74101 |
| Bank of the West | 2200 East Lincoln Way | Cheyenne | WY | 82001 |
| Barbara A. Ittig | 44265 Compeigne Drive | Hemet | CA | 92544 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Barry A. Craft | 6416 Aston Park Drive | Oak Ridge | NC | 27310 |
| Barry S. Farris & Gralyn J. Farris, hw | 1544 South Pitkin Circle | Aurora | CO | 80017 |
| Basin Electric Power Cooperative | 1717 E. Interstate Avenue | Bismarck | ND | 58503 |
| BCP Energy, LLC | P.O. Box 472059 | Fort Worth | TX | 76147 |
| Beauleo Minerals, LLC | 5 Brighton Way | Farmington | CT | 06032 |
| BEIF #2, LLC | 475 17th Street, Suite 570 | Denver | CO | 80202 |
| Bernard Caputo | 34 Woodcrest Road | Boxford | MA | 01921 |
| Bert J. Farris | 3931 Granite Street | Cheyenne | WY | 82001 |
| Beth and Ken Karmin Family Trust | 1555 Capri Drive | Pacific Palasades | CA | 90272 |
| BFG Minerals, LLC | 225 S. Broadway, Suite 9847 | Denver | CO | 80209 |
| BHCH Mineral, Ltd. | 5111 Broadway | San Antonio | TX | 78209 |
| Bill Barkley | 10115 Branding Iron Drive | Cheyenne | WY | 82009 |
| Bill Barrett Corporation | 1099 18th Street, Suite 2300 | Denver | CO | 80202 |
| Billy Nokes and Emily Nokes | 315 2nd Street | Carpenter | WY | 82054 |
| Blaine W. Barker | 4834 Adams Ave | Carpenter | WY | 82054 |
| Blaise E. McEwan | 5825 Bay Point Drive | Lake Oswego | OR | 97032 |
| Blue Federal Credit Union | P.O. Box 3200 | Cheyenne | WY | 82003 |
| Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 |
| Bluebird Energy Partners, LLC | 9055 E. Mineral Circle, Suite 110 | Centennial | CO | 80112 |
| BNSF Railway Company | 2650 Lou Menk Drive | Fort Worth | TX | 76131-2830 |
| Bold Resources, LLC | 6615 West Rowland Avenue | Littleton | CO | 80128 |
| Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 |
| Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 |
| Brenda Jo Millikin | 4727 Road 205 | Carpenter | WY | 82054 |
| Brent A. Oswald | 1304 Yorkshire Drive | Austin | TX | 78723 |
| Brian H. Davis | 628 Aqua Circle | Lino Lakes | MN | 55014 |
| Brian M. Foster | 13824 West Amherst Way | Lakewood | CO | 80228 |
| Brian Summer | 46 Conway Street, Suite B | Shellburne Falls | MA | 01370 |
| Brighton Mineral Holdings, LLC | P.O. Box 669 | Englewood | CO | 80151-0669 |
| Bryon P. and Peggy A. Veal | 5855 East 124th | Brighton | CO | 80601 |
| Bulldog Energy , LLC | 2460 W. Caithness Place, Unit 207 | Denver | CO | 80211 |
| Burdine W. Rogers, Jr. | 4771 Road 206 | Carpenter | WY | 82054 |
| Burnett Land & Livestock, Ltd. | 5453 County Road 202 | Carpenter | WY | 82054 |
| C Three J, LLC | 13705 Highway 11 | Allendale | IL | 62410 |
| Caldwell Banker The Property Exchange | 255 Storey Boulevard | Cheyenne | WY | 82009 |
| Calf Creek Royalty, Ltd. | P.O.Box 3240 | Midland | TX | 79702 |
| Camden Carol Lorenz | P.O. Box 1863 | Lihue | HI | 96766 |
| Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 |
| Carol M. Bradley Living Trust | 1951 Fern Court | Kissimmee | FL | 34743 |
| Carolyn Hern and Gerald L Hern | 55 Barstow Bridge Road | Kettle Falls | WA | 99141 |
| Carpenter Cemetery | Road 204 | Carpenter | WY | 82054 |
| Carpenter Christian Fellowship Church | 4858 Adams Ave | Carpenter | WY | 82054 |
| Carpenter Water and Sewer District | P.O. Box 433 | Carpenter | WY | 82054 |
| Cassandra Carroll, c/o Lindvall Neil | 4838 Monroe Avenue | Carpenter | WY | 82054 |
| Cassandra Carroll, c/o Lindvall Neil | 208 E. Prosser Rd. | Cheyenne | WY | 82007 |
| Cassandra J. Ward | 21833 Hisle Road | Martin | SD | 57551 |
| Catherine M. Enzo | 12230 Cherry Street | Thornton | CO | 80241 |
| Catholic Relief Services | 228 W. Lexington St. | Baltimore | MD | 21201-3443 |
| CBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 |
| CBK Investments, LLC | P.O. Box 21468 | Tulsa | OK | 74121 |
| Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 |
| CECO, LLC | P.O. Box 102076 | Denver | CO | 80250 |
| Center of Action and Contemplation | P.O. Box 12464 | Albuquerque | NM | 87195 |
| Charlene K. Gordon and John G. Gordon | 796 Road 154 | Carpenter | WY | 82054 |
| Charles Edgar | Unknown Address | | | |
| Charles Fuller 2006 Trust, Charles F. Fuller, Trustee | 722 Jacaranda Circle | Hillsborough | CA | 94010 |
| Charles J. and Caroline J. Edgar | 1225 SE 260th Road | Clinton | MO | 64735 |
| Charles R. Hammond | Unknown Address | | | |
| Charles W. and Patty N. Brown, LLC | 6408 Outabounds Court | Oklahoma City | OK | 73116 |
| Charles W. and Patty N. Brown, LLC | P.O. Box 587 | Marlow | OK | 73055 |
| Charles W. Austin | P.O. Box 1153 | Billings | MT | 59103 |
| Charles Y. Lu and Felice S. Huang | P.O. Box 20303 | Cheyenne | WY | 82003 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Charlotte L. Sharp | 21833 Hisle Road | Martin | SD | 57551 |
| Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 |
| Cherry Creek Mortgage, LLC | 7600 East Orchard Road, Suite #250-N | Greenwood Village | CO | 80111 |
| Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 |
| Cheyenne Light, Fuel and Power Company | P.O. Box 1409 | Cheyenne | WY | 82003 |
| Cheyenne Light, Fuel and Power Company | 1301 W. 24th Street | Cheyenne | WY | 82001 |
| Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 |
| Chris Woll | 5815 Republic of Texas Blvd. | Austin | TX | 78735 |
| Christopher H. and Amy Lynn Clark | 4533 Teepee Road | Carpenter | WY | 82054 |
| Cindy I. Johnston, Trustee under the Cindy I. Johnston Living Trust dated 04-15-2014 | 609 Artesian Road | Cheyenne | WY | 82007 |
| Cindy Jo Hamilton | P.O. Box 214 | Hillsdale | WY | 82060 |
| Cirque Brennsee, LLC | 475 17th Street, Suite 1600 | Denver | CO | 80202 |
| Clayton Derstine & Sonya Derstine, hw | P.O. Box 358 | Carpenter | WY | 82054 |
| Clear Creek Fund I-A, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 |
| Clear Creek Fund I-B, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 |
| Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 |
| CLH - Minerals, LLC | P.O. Box 3759 | Manhattan Beach | CA | 90266 |
| CNOOC Energy U.S.A. LLC | 945 Bunker Hill Road, Suite 1000 | Houston | TX | 77024 |
| Cody E. and Laura Jo Howes | 4566 Buggy Road | Carpenter | WY | 82054 |
| Cody E. and Laura Jo Howes | 9039 South Greenspoint Lane | Highlands Ranch | CO | 80130 |
| Cody L. Smith | 291 Road 152 | Carpenter | WY | 82054 |
| Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 |
| Community Investments, Inc. | P.O. Box 653 | Cheyenne | WY | 82003 |
| Connie Faye Snyder | 8203 A Wyncote Rd | Lingle | WY | 82223 |
| Connie Lou Rivas | 751 Avenue C, #45-45 | Cheyenne | WY | 82007 |
| Cory Morgan and Heather Morgan | 313 2nd Street | Carpenter | WY | 82054 |
| Courtney R. Jones | 10810 Yeomans Park Drive | Colorado Springs | CO | 80908 |
| Covault Resources, LLC | 101 Cook St, Suite 3000 | Denver | CO | 80206 |
| Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 |
| Cox Minerals LLC | 2812 1st Avenue North | Billings | MT | 59103 |
| Cox Minerals LLC | P.O. Box 2015 | Billings | MT | 59103-2015 |
| Craig and Alaina Goble | 1480 Gilchrist Road | Cheyenne | WY | 82009 |
| Craig L. Emmanuel | P.O. Box 86 | Laramie | WY | 82073 |
| Crow Creek Cattle, LLC | 7678 Road 17 | Fort Lupton | CO | 80621 |
| Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 |
| Curzon Management, LLC | 1116 Wiltshire Avenue | San Antonio | TX | 78209 |
| Curzon Management, LLC | 408 Canterbury Hill | San Antonio | TX | 78209 |
| Cynthia K. and Harold V. Stroot | Unknown Address | | | |
| Dale A. Swanson | 339 Indian Paintbrush Drive | Golden | CO | 80401 |
| Dale Harlan | 7005 Wagon Train Road | Hickman | NE | 68372 |
| Dale Mitchell and Judy M. Mitchell | P.O. Box 356 | Lyle | WA | 98635 |
| Dale R. and Sharon Martin | 324 County Road 148 | Carpenter | WY | 82054 |
| Dallas C. Harrigfeld | P.O. Box 20303 | Cheyenne | WY | 82003 |
| Darlene Hughes | P.O. Box 1115 | Kettle Falls | WA | 99141 |
| David A. Dent | 6712 Arrowhead Pass | Edina | MN | 55439 |
| David Brookens | 556 Central Avenue | Beach | ND | 58621 |
| David Bruce Soppe Living Trust | P.O. Box 4 | Kaycee | WY | 82639 |
| David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 |
| David F. Stagg | 9609 239th Street North | Port Byron | IL | 61275 |
| David G. Majewski | 11823 South Maxwell Hill Road | Littleton | CO | 80127 |
| David Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 |
| David J. Leastman and Lorayne A. Leastman | 4849 E. Adams Avenue | Carpenter | WY | 82054 |
| David John Leastman II | 320 5th Street | Carpenter | WY | 82054 |
| David John Leastman II and Regina Raye Leastman | 320 5th Street | Carpenter | WY | 82054 |
| David Lindsey Kirchgessner | 13113 Orienta Avenue NE | Albuquerque | NM | 87123 |
| David M. Jesse | 51 Eldred | Bedford | OH | 44146 |
| David Soppe | P.O. Box 4 | Kaycee | WY | 82639 |
| David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 |
| David W. Galehouse and Deborah K. Hartman, JT | 3216 Deweese Parkway | Dayton | OH | 45414 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Debora A. Waymire | 5325 W. Kerry Lane | Glendale | AZ | 85308 |
| Deborah A. Campbell aka Debra A. Campbell | P.O. Box 596 | Martin | SD | 57551 |
| Deborah L. Shepardson | 811 Heather Lane | Montrose | CO | 81401 |
| Debra Ann Jackson | P.O. Box 75 | Burns | WY | 82053 |
| Del Rio Royalty Company, LLC | 3400 S. Broadway, Suite 100 | Englewood | CO | 80113 |
| Dennis J Seidl | 4846 Monroe Ave | Carpenter | WY | 82054 |
| Dennis W. Yockim | 8765 Greensborough Place | Littleton | CO | 80129 |
| Derk Smith | 3321 Heritage Lake Drive | Lockport | IL | 60441 |
| Diana K. Acheson and Fred L Acheson, Co-Trustees of he Fred L. Acheson and Diana K. Acheson Joint Revocable Trust U/A dated 10-16-2015 | P.O. Box 220 | Hillsdale | WY | 82060 |
| Dimple Dene Hummer | 5901 Forest Ledge | San Antonio | TX | 78240 |
| DJ Resources Holdings, LLC | One Riverway, Suite 1870 | Houston | TX | 77056 |
| Don A. Kranz, Trustee of the Don A. Kranz Revocable Trust, dated April 27, 2016 | 493 County Road 154 | Carpenter | WY | 82054 |
| Don S. Poelma and Gayle L. Poelma | 6515 Armant Ct | Cheyenne | WY | 82009 |
| Donald A. and Stacy L. Edgar | 17892 Bagby Road | Green Ridge | MO | 65332 |
| Donald A. Syvanen and Mary Ann Syvanen | P.O. Box 472 | Carpenter | WY | 82054 |
| Donald W. Bubar | 10408 Creighton Road | SW Fife Lake | MI | 49633 |
| Donna M. Ford as Trustee of the Gary R. Ford and Donna M. Ford Revocable Trust, dated August 26, 2005 | 3840 SR 209 | Boroadview | NM | 88112 |
| Donna Rogers and Jeffrey Douglas | 707 S. Table Mountain Loop | Cheyenne | WY | 82009 |
| Double Eagle Energy Rockies, LLC | 1401 Ballinger Street, Suite 203 | Fort Worth | TX | 76102 |
| Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 |
| E. Lee Tower | Box 1770 | Redlodge | MT | 59068 |
| Earl Eugene Noel & Donna C. Noel | P.O. Box 639 | Martin | SD | 57551 |
| Edith E. Lang, Trustee, or her successors in trust, of the Edith E. Lang Living Trust, dated 4/5/1999 | P.O. Box 37, Route 1 | Carpenter | WY | 82054 |
| Edmond Cook and Tena L. Cook | P.O. Box 1327 | Chadron | NE | 69337 |
| Edward A. Kranz and Julie C. Kranz | 484 County Road 151 | Carpenter | WY | 82054 |
| Edward N. Strader and Carol N. Strader, JTwROS | 3718 Dover Road | Cheyenne | WY | 82001 |
| Edwin K. Smith, Jr. and Lucinda I. Smith, husband and wife | 4890 CR 205 | Carpenter | WY | 82054 |
| Elah and Margaret B. Helper | 6009 East Boise Street | Mesa | AZ | 85205 |
| Elenor Stagg King | P.O. Box 3033 | Clinton | IA | 52732 |
| Elizabeth L. Willoughby & Robert F. Willoughby, wh | 142 Flagstaff Way | Buffalo | WY | 82834 |
| Ellen Crowley, Attorney In Fact for Leota Russel aka Leota M. Russell | P.O. Box 287 | Cheyenne | WY | 82003 |
| Elsie Bettge | 1217 Spruce Dr. | Knoxville | TN | 37920 |
| ELSR LP, A Texas Limited Partnership, Bengal Jones Group LLC, General Partner | 8080 North Central Expressway, Suite 1420 | Dallas | TX | 75206 |
| Emmanuel Farm LLP | 220 Road 148 | Carpenter | WY | 82054 |
| Enerquest Oil & Gas, L.L.C. | 12368 Market Drive | Oklahoma City | OK | 73114 |
| EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 |
| EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 |
| Equity Trust Company Custodian FBO Arthur J. Powell Jr. IRA | P.O. Box 1529 | Elyria | OH | 44035 |
| Equity Trust Company Custodian FBO Gary F. Hansen IRA | 225 Burns Road | Elyria | OH | 44035 |
| Equity Trust Company Custodian FBO Kent Nygren IRA | 225 Burns Road | Elyria | OH | 44035 |
| Equity Trust Company Custodian FBO Matthew V. Lee JR., Roth IRA #43612F77 | 225 Burns Road | Elyria | OH | 44035 |
| Eric Wilt | P.O. Box 1473 | Williston | ND | 58802 |
| Esther M. Lewis and Duwayne Lewis | 10905 Empire Dr. | Cheyenne | WY | 82009 |
| ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 |
| Evans Community Park | P.O. Box O | Carpenter | WY | 82054 |
| Everett Rhodes | P.O. Box 447 | Carpenter | WY | 82054 |
| Evergreen Pipeline, Inc | 4842 Road 203 | Carpenter | WY | 82054 |
| Exodus Energy, LLC | 1474 S. Saint Paul St. | Denver | CO | 80210 |

Notification 43N-72W-36
Campbell County, Wyoming

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Exterra Resources, LLC | 256 Seaboard Lane, H101 | Franklin | TN | 37067 |
| Extraction Oil & Gas LLC | 370 17th St., Ste 5200 | Denver | CO | 80202 |
| Ezra Derstine c/o Matthew Derstine | 331 Second Street | Carpenter | WY | 82054 |
| Faith Partners Land Company, LLC | 4772 Tara Ct. | West Bloomfield | MI | 48323 |
| Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 |
| Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 |
| Fanny L. Malm, Trustee of the Gordon Malm Revocable Trust dated 02/20/1998 | 6360 State Highway 216 | Albin | WY | 82050 |
| Faris Hawkins | 2275 Squak Mountain Loop SW | Issaquah | WA | 98027 |
| Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 |
| Farm Credit Services of America, FLCA | 5015 S. 118th Street | Omaha | NE | 68103-2409 |
| Farm Service Agency | 1502 Progress Court | Wheatland | WY | 82201 |
| Farm Service Agency | 1560 B-Johnston Street | Wheatland | WY | 82201 |
| Farmer Family Trust | 5135 Syracuse Road | Cheyenne | WY | 82009 |
| Farmers & Merchants Bank of Colby | P.O. Box 797 | Colby | KS | 67701 |
| Farmers Bank | P.O. Box 220 | Ault | CO | 80610 |
| Farmers State Bank | P.O. Box 252 | Chadron | NE | 63337 |
| Father Richard Rohr aka The Reverend Richard Rohr, O.F.M. | P.O. Box 12464 | Albuquerque | NM | 87195 |
| Fifth Creek Energy Operating Company, LLC | 5251 DTC Parkway, Suite 420 | Greenwood Village | CO | 80111 |
| Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 |
| First Interstate Bank | P.O. Box 1098 | Torrington | WY | 82240 |
| First Interstate Bank | 401 W. 9th Street | Cheyenne | WY | 82001 |
| First Interstate Bank | P.O. Box 1710 | Cheyenne | WY | 82001-1710 |
| First State Bank, Division of Glacier Bank, Torrington Branch | P.O. Box 1098 | Torrington | WY | 82240 |
| Food for the Poor, Inc. | 6401 Lyons Road | Coconut Creek | FL | 33073 |
| Fossil Creek Land Company | P.O. Box 485 | Mustang | OK | 73064 |
| Francis Cushing | Unknown Address | | | |
| Francis Edward Oline Intervivos Trust, dated 11/5/2003 | 1522 Copperville Road | Cheyenne | WY | 82001 |
| Francis W. and E. Joanne Blake | P.O. Box 79 | Hereford | CO | 80732 |
| Francis W. Blake | 5700 East CR 48 | Fort Collins | CO | 80524 |
| Francis W. Blake, Trustee of the Ettie P. Blake Living Trust, dated 08-15-1988 | 5700 East CR 48 | Fort Collins | CO | 80524 |
| Frank Worthington aka Frank Walterstein, heir of Harriett Stanton Walterstein aka Harriett Stanton Worthington aka Harriett Stanton Gilleas, heir of Harlett Isabel Stanton | 1200 Mira Mar Ave. #931 | Medford | OR | 97504 |
| Fred L. Acheson and Diana K. Joint Revocable Trust | P.O. Box 220 | Hillsdale | WY | 82060 |
| Fredericksburg Royalty, Ltd | 5111 Broadway | San Antonio | TX | 78209 |
| Freedom Mortgage Corporation | 951 Yamoto Road, Suite 175 | Boca Raton | FL | 33431 |
| FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 |
| G & G Enterprises of WY, LLC | 255 Storey Boulevard | Cheyenne | WY | 82009 |
| Gary A. Weber and Christine D. Weber | 4619 County Road 207 | Carpenter | WY | 82054 |
| Gary and Karen McCallister | Unknown Address | | | |
| Gary Breeden | Unknown Address | | | |
| Gary D. Rohrbouck | 2170 Pacific Road | Gering | NE | 69341 |
| Gary Larson and Jeanine D. Larson, JT | 715 N. 25th St | Mesa | AZ | 85213 |
| Gary P. and Norma Jean Smith | P.O. Box 365 | Carpenter | WY | 82054 |
| Gary R and Donna M. Ford Revocable Trust | 3840 SR 209 | Broadview | NM | 88112 |
| Gary Smith Family Living Trust | P.O. Box 26 | Hereford | CO | 80732 |
| GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 |
| Gene E. Miller | P.O. Box 68 | Chappell | NE | 69129 |
| Gene G. Purdy | Unknown Address | | | |
| George A. Longo | 505 North West CR 0011 | Corsicana | TX | 75110 |
| George G. Vaught, Jr. | P.O. Box 13557 | Denver | CO | 80201 |
| Gerald E. Werner | 10254 South 700 West | Union Mills | IN | 46382 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Gerald R. and Carl E. Zimmerman, co-trustees of the Laura E. Zimmerman Family Trust, created 5/29/2006 | Unknown Address | | | |
| Gerald W. Simonson | 5813 Jeff Place | Edina | MN | 55436 |
| Gilbert M. Weaver and Karen W. Weaver | 4829 Road 201 | Carpenter | WY | 82054 |
| Gordon Malm Revocable Trust | P.O. Box 55 | Albin | WY | 82050 |
| Grace Valley, LLC | P.O. Box 391 | Carpenter | WY | 82054 |
| Grace Valley, LLC | 316 E. 1st Street | Carpenter | WY | 82054 |
| Grady Faris and Janice Faris | 1854 18th Street | Wheatland | WY | 82201 |
| Grant W. Avery Declaration of Trust dated 6/20/2008 | 15543 Southeast Frontage Road | Plainfield | IL | 60544 |
| Grayrock Minerals, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 |
| Gregory Gene Arp | Box 332 | Bennet | NE | 68317 |
| Guild Mortgage Company | 5898 Copley Drive | San Diego | CA | 92111 |
| Guy Faris | 179 Indian Ridge Road | Pavillion | WY | 82523 |
| Halliburton Energy Services, Inc. | 3000 N. Sam Houston Parkway East | Houston | TX | 77032 |
| Halliburton Energy Services, Inc. | 2107 City West Blvd., Building 2 | Houston | TX | 77042 |
| Harold F. Baumgartner | Unknown Address | | | |
| Harold R. Barr | 4299 South 75 West | Laporte | IN | 46350 |
| Harold V. Stroot and Cynthia K. Stroot | P.O. Box 76 | Burns | WY | 82053 |
| Harrower Ranches LLC | 8603 Powderhouse Road | Cheyenne | WY | 82009 |
| Harvey Miller | Unknown Address | | | |
| Heather Montgomery | 3907 East 12th | Spokane | WA | 99202 |
| Heidi Rehwinkel Moore | 13500 Road W | Weldona | CO | 80653 |
| Henry Earl and Margaret D. Montgomery | 4022 E. 9th Street | Cheyenne | WY | 820041 |
| High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 |
| Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 |
| HK Oil & Gas, LLC | P.O. Box 95285 | South Jordan | UT | 84095 |
| HOG BG, LLC | P.O. Box 526412 | Salt Lake City | UT | 84152 |
| Howard and Elsie Rose Evans | Unknown Address | | | |
| HRM Resources II, LLC | 410 17th Street, Suite 1100 | Denver | CO | 80202 |
| Hydrocarbon Holdings, LTD | P.O. Box 1135 | Bridgeview | IL | 604555 |
| Hydrocarbon Minerals II, LLC | P.O. Box 2157 | Bridgeview | IL | 60455 |
| In God We Trust No 1 Revocable Trust In God We Trust No 2 Revocable Trust | 324 County Road 148 | Carpenter | WY | 82054 |
| Incline Niobrar Parnters, L.P. | 5019 N. Central Expressway, Suite B | Dallas | TX | 75205 |
| International Lutheran Laymen's League | 660 Mason Ridge Center Dr. | St. Louis | MO | 63141 |
| IRA Resources, Inc,, FBO: Harry W. Buehrle, II IRA 32486 | 6825 La Jolla Boulevard | La Jolla | CA | 92037 |
| Ivan K. Gilling | 14250 County Road AA | La Jara | CO | 81140 |
| Ivan L. Kranz and Kimberly K. Kranz Joint Rev Trust | P.O. Box 129 | Burns | WY | 82053 |
| Ivan Lee Kranz | 861 County Road 150 | Carpenter | WY | 82064 |
| J. Christopher Dykes, as Trustee of The J. Christopher Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 |
| J. E. Taylor | 1925 Grand Avenue | Billings | MT | 59102 |
| J.R. Carpenter c/o Evans Park Board | P.O. Box 5 | Carpenter | WY | 82054 |
| J15, LLC | P.O. Box 31749 | Palm Beach Gardens | FL | 33420 |
| Jack E. Earnest | 5945 Shady Circle Drive | Houston | TX | 77057 |
| Jack Faris | Unknown Address | | | |
| James A. Hammond | Unknown Address | | | |
| James David and Kathleen Edna Young | Unknown Address | | | |
| James E. and Kina M. Costello Family Trust dated December 23, 1999 | 613 SW Drive | Cheyenne | WY | 82007 |
| James E. Edgar aka James Eugene Edgar | 1906 Euclid | Wichita | KS | 67213 |
| James L. Rodebaugh & Maria J. Rodebaugh, hw | 4875 County Road 203 | Carpenter | WY | 82054 |
| James M. Konig | 57851 WCR 81 | Grover | CO | 80729 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| James Michael Morris | 2121 Redhead Dr | Johnstown | CO | 80534 |
| James Patrick Sullivan and Deanna C. Sullivan | 11413 Glencoe Drive | Cheyenne | WY | 82009 |
| James S. Witherell Trust Dated 6/17/1997, James S. Witherell, Trustee | 2610 Deep Cut Road | Woodstock | IL | 60098 |
| James S. Worthington aka James Stanton Worthington aka Jim S. Worthington aka James Stanton Walterstein | 559 7th St. W | Sonoma | CA | 95476 |
| Jane E. Pihl | 15648 SW Highway 126 | Powell Butte | OR | 97753 |
| Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 |
| Janet I. Stanton, a widow | 3086 Stadium Ave | Napa | CA | 94558 |
| Janet Iokepa | 415 Keonaona Street | Hilo | HI | 96720 |
| Janice Ann Taylor aka Jan Taylor aka Janice A. Taylor | 636 E. Magnesium Rd. Apt C-111 | Spokane | WA | 99208 |
| Jared Montgomery | 3907 East 12th | Spokane | WA | 99202 |
| Jared Rush | 4481 Quitman Street | Denver | CO | 80212 |
| Jason and Mona Castle | 4528 Buggy Road | Carpenter | WY | 82054 |
| Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 |
| Jason W. Smith and Lisa J. Smith | P.O. Box 401 | Carpenter | WY | 82054 |
| Jeanie M. Grogan | 613 SW Drive | Cheyenne | WY | 82007 |
| Jeff and Molly Williams Family Revocable Family Trust | 1418 E 21st Street | Cheyenne | WY | 82001 |
| Jeff Tracy | 1416 8th Avenue | Scottsbluff | NE | 69361 |
| Jeffery C. and Danielle D. Hackett | 4566 Buggy Road | Carpenter | WY | 82054 |
| Jeffery L. and Melissa A. Matney | 4514 Teepee Road | Carpenter | WY | 82054 |
| Jeffery W. Hamel | 8310 Heather Avenue | Eden Prairie | MN | 55347 |
| Jeffery William and Daniella LeNea Allman | 4761 Road 206 | Carpenter | WY | 82054 |
| Jeffrey B. Farris & Mary Ann Farris, hw | P.O. Box 751 | Byers | CO | 80103 |
| Jeffrey C. Mauck | 405 Elm Street | Spring Valley | IL | 61362 |
| Jeffrey E. Spence Revocable Trust | 4816 Road 203 | Carpenter | WY | 82054 |
| Jeffrey L. and Melissa A. Matney | 4514 Teepee Road | Carpenter | WY | 82054 |
| Jerald F. Sidwell | 4481 Road 203 | Carpenter | WY | 82054 |
| Jeremy Russell and Tanya Marie Evans | 5680 Road 228 | Albin | WY | 82050 |
| Jerry E. and Roxie C. Anderson | 4455 Teepee Road | Carpenter | WY | 82054-9109 |
| Jerry L. Burnett and Margaret E. Burnett | P.O. Box 4 | Hereford | CO | 80732 |
| Jerry L. Burnett and Margaret E. Burnett | 4834 Monroe Avenue | Carpenter | WY | 82054 |
| JFK Ag, LLC | 37174 County Road 124 | Grover | CO | 80729 |
| JH Petroleum, LLC | P.O. Box 621128 | Littleton | CO | 80162-1128 |
| Jill Jahn, aka Jill Tower aka Jill F. Tower | P.O. Box 156 | Fishtail | MT | 59222 |
| Jim Clayton | 1258 Whispering Oaks | Desoto | TX | 75115 |
| Jim Mamot | 233 Friend Road | St. Liberty | NE | 68872 |
| Jimmie D. Collins | 4408 E. 6th St. | Cheyenne | WY | 82001 |
| Jimmie Dee Talkington | Box 224 | Hillsdale | WY | 82060 |
| Jimmy Lee Alexander | P.O. Box 178 | Kingfisher | OK | 73750 |
| JKW, LLC | 255 Storey Boulevard | Cheyenne | WY | 82009 |
| JLW Investment, LLC | 351 Glencoe Street | Denver | CO | 80220 |
| Joann Soto | 3338 Vanvelzor #B | Cheyenne | WY | 82001 |
| Joanne E. Brown-Vossler | 1030 Washington Street | Douglas | WY | 82633 |
| Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 |
| John A. Barela Revocable Trust | 314 5th St | Carpenter | WY | 82054 |
| John and Mona Castle | 4528 Buggy Road | Carpenter | WY | 82054 |
| John C. Peterson and Bernadette J. Peterson, JT | 12472 89th Place | Maple Grove | MN | 55369 |
| John Dean | P.O. Box 1028 | Gilmer | TX | 75644 |
| John Ferrera | 4833 Adams Avenue | Carpenter | WY | 82054 |
| John Francis and Ardith A. Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 |
| John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 |
| John H. Hueske | Unknown Address | | | |
| John L. and Janet I. Farmer | 5135 Syracuse Road | Cheyenne | WY | 82009 |
| John R. Sellers | 4019 West 176th Street | Torrance | CA | 90504 |
| John S. Belcher, LLC | 235 South High Street | Denver | CO | 80209 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| John Scott Gibson and Judy A. Gibson | 16838 Morgan Road 10 | Fort Morgan | CO | 80701 |
| John Spicer | 5956 Bannock Hwy | Pocatello | ID | 83204 |
| Johnnie Christensen and Patsy Christensen | 5200 Allan Road | Cheyenne | WY | 82009 |
| Joleen Springer | 6241 Donnington Court | Sarasota | FL | 34238 |
| Jon J. Dalton | 335 N 1st | Carpenter | WY | 82054 |
| Jonah Bank of Wyoming | 777 West 1st Street | Casper | WY | 82601 |
| Jonea R. Fuller and James L. Fuller | 285 Crossbow Dr | Green River | WY | 82935 |
| Jonna Rehwinkel Lewis | 13500 Road W | Weldona | CO | 80653 |
| Joseph and Allison Ward | 535 Road 143 | Carpenter | WY | 82054 |
| Joseph G. Lynch | P.O. Box 4308 | Williston | ND | 58802 |
| Joseph J. Poelma and Patricia Poelma c/o Ronald E. Poelma | 8351 Buckboard Road | Cheyenne | WY | 82009 |
| Joshua C. Rohde | 4834 Road 203 | Carpenter | WY | 82054 |
| Joshus D. Vance and Brandy E. Vance, JT | 108 Woodland Drive | Krugerville | TX | 76227 |
| Joyce P. Andrews | 4825 Monroe Avenue | Carpenter | WY | 82054 |
| JP Morgan Chase Bank, N.A. | 1125 17th St., Floor 2 | Denver | CO | 80202 |
| Judith L. Avery | 23524 West Copper Drive | Plainfield | IL | 60544 |
| Judy F. Payne and Dale Payne | 41 Dalton Road | Omak | WA | 98841 |
| Judy Likwartz | 5916 N. Wilbur Ave. | Portland | OR | 97217 |
| Julian Bott | 2449 Westlake Drive | Austin | TX | 78746 |
| June Cushing | Unknown Address | | | |
| Justin A. and Karen A. Morrison | 512 Road 146 | Carpenter | WY | 82054 |
| Kaiser-Francis Mid-Continent Limited Partnership | P.O. Box 2280 | Tulsa | OK | 74101 |
| Kaiser-Francis Oil Company | P.O. Box 21468 | Tulsa | OK | 74121 |
| Karen Ankers | 4836 Monroe Avenue | Carpenter | WY | 82054 |
| Karen Anne Breeder | 631 Ash Street | Windsor | CO | 80550 |
| Karen R. Jenkins | 20030 WCR 33 | LaSalle | CO | 50645 |
| Karhu Resources LLC | P.O. Box 272229 | Fort Collins | CO | 80527 |
| Karl A. Glastad | 8 Sunset Trail | Heath | TX | 75032 |
| Karl A. Willey Rev. Trust, Karl A. Willey, Trustee | 412 North Young | Caldwell | KS | 67022 |
| Karl Schreiber | 5100 Miller Road | Brecksville | OH | 44141 |
| Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 |
| Kathaleen Ann Eastman-Lorenz | P.O. Box 1863 | Lihue | HI | 96766 |
| Katherine Tippy Castello aka K. Tippy Costello | 1209 W. 22nd Street | Cheyenne | WY | 82001 |
| Kathleen Eastman-Lorenz, Successor Trustee of the Michael Philip Lorenz Revocable Living Trust | P.O. Box 1863 | Lihue | HI | 96766 |
| Kathleen Kay Arp Woolbright | 311 S. Tennessee St. | Amarillo | TX | 79106 |
| Kathy Marie Hammons | 4840 Adams Ave. | Carpenter | WY | 82054 |
| Keith E. Montgomery | 305 Ave A | Battle Creek | MI | 49015 |
| Keith Michael Foster and Lisa Marie Foster, JTwROS | 13824 West Amherst Way | Lakewood | CO | 80228 |
| Keith Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 |
| Keith Tower and Martha J. Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 |
| Keke Lu and Yong Cao | 6 Myrtle Dr | Acton | MA | 01720 |
| Kelly V. Oswald | 5638 Sanford Road | Houston | TX | 77096 |
| Ken Ward and Janet Ward, JT | 732 Bluff Ridge Drive | Cedar Hill | TX | 75104 |
| Kenneth W. Morris | 2121 Haas Road | Apopka | FL | 32712 |
| Kent E. Harlan | 822 N. 7th St. | Beatrice | NE | 68310 |
| Kestrel Properties Corp. | P.O. Box 3972 | Morrison | CO | 80465 |
| Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 |
| Kevin and Lynn Emery | 4613 Road 206 | Carpenter | WY | 82054 |
| Kevin J. Dobbs and Jami L. Dobbs | 324 Main Street | Carpenter | WY | 82054 |
| Kimberly T. Dunn | 2631 W. Dell Drive | Spokane | WA | 99208 |
| Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 |
| Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 |
| Kristy Jean McKinney | 348 N 1st St. | Carpenter | WY | 82054 |
| Kyle D Shutt, as Trustee of the Kianna Royalty Trust, a Revocable Trust dated 3/1/19933 | P.O. Box 20571 | Oklahoma City | OK | 73156 |
| Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 |
| Kyle W. Breeden and Katherine Tippy Costello, hw as t/b/e | 149 County Road 143 | Carpenter | WY | 82054 |
| L P R Investment South, LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Lance Lacy and Tricia Lacy | 15741 W. Ventura Street | Surprise | AZ | 85379 |
| Laramie County Fire Protection Dist 4 | P.O. Box 5 | Carpenter | WY | 82054 |
| Laramie County School District No. 2 | 4814 Monroe Ave | Carpenter | WY | 82054 |
| Laramie Operating LLC, a Colorado limited liability company | 1120 Lincoln Street, Suite 1605 | Denver | CO | 80203 |
| Larry E. Seitz M.D., Trustee of the Larry E. Seitz Revocable Trust, dated 3/11/1981 | 219 Palm Springs Avenueast | Cheyenne | WY | 82009 |
| Larry J. Lembitz and Diana L. Lembitz | Unknown Address | | | |
| Larry Williams, Penny E. Martin and Vera E. Williams | 4832 Adams Ave | Carpenter | WY | 82054 |
| Laura Lee Bates | 12229 Yellowstone Road NE | Albuquerque | NM | 87111 |
| Leaning Tree Homes, Inc. | 1740 Dell Range Boulevard, Suite 423 | Cheyenne | WY | 82009 |
| Lela Sue Dennis | Box 6 | Lingle | WY | 82223 |
| Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 |
| Leo Smith and Janet Smith | 115 Road 153 | Carpenter | WY | 82054 |
| Leona Buhlmann | 42473 Drive 743 | Elwood | NE | 68937 |
| Leona I Price | P.O. Box 161 | Burns | WY | 82053 |
| Leonarda Oberwise, Trustee under the Leonarda Oberwise Trust dated 07-12-2023 | 484 Road 143 | Carpenter | WY | 82054 |
| Leopoldo Rodriguez | 4206 Ridgelane Drive | Colorado Springs | CO | 80918 |
| Leroy and Marilyn Wiens | 511 Road 146 | Carpenter | WY | 82054 |
| Lester D. True, Trustee, or his successors in trust, under the Lester D. True Living Trust dated 1/17/2003 | 274 Road 147 | Carpenter | WY | 82054 |
| Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 |
| Lillian E. Harrower Revocable Mineral Trust, dated 11/2/2007 | 8603 Powderhouse Road | Cheyenne | WY | 82009 |
| Lincoln Energy Partners IV, LLC | 3400 S. Broadway, Suite 100 | Englewood | CO | 80113 |
| Lincoln Energy Partners, LLC | 852 Broadway, Suite 300 | Denver | CO | 80203 |
| Lincoln Energy Partners, LLC | P.O. Box 6975 | Denver | CO | 80206 |
| Linda D. and Stephen G. Nelson | 5200 N.E. 69th Terrace | Kansas City | MO | 64119 |
| Linda Edgar | Unknown Address | | | |
| Linda L. Lankford | 4573 Road 206 | Carpenter | WY | 82054 |
| Lloyd W. Hammond | Unknown Address | | | |
| Longs Peak Resources, LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 |
| Lonnie D. Fiscus and Marjorie A. Fiscus | 4834 Main Street | Carpenter | WY | 82054 |
| LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 |
| LOR Capital I, LLC | 1120 Lincoln Street, Suite 1605 | Denver | CO | 80203 |
| Lorraine Smith | 4696 CR 204 | Carpenter | WY | 82054 |
| Lost River Trading Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 |
| Louis A. Oswald, III, Trustee fo the Oswald Family Trust, dated April 27, 1998 | P.O. Box 280969 | Lakewood | CO | 80228-0969 |
| Loyd Farms, GP, James A. and Lonna J. Loyd | 66732 WCR 136 & 87 | Hereford | CO | 80732 |
| LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 |
| Lucinda I. Smith | 4890 CR 205 | Carpenter | WY | 82054 |
| Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 |
| Lynn Warner, Matthew Yoder and Janel Yoder | 332 3rd Street | Carpenter | WY | 82054 |
| Lynne M. Kranz, Trustee of the Lynne M. Kranz Revocable Trust, dated April 27, 2016 | 493 County Road 154 | Carpenter | WY | 82054 |
| Lynx Oil Company | 9736 West Swarthmore Drive | Littleton | CO | 80123 |
| M&P Concrete, Inc. | P.O. Box 2096 | Cheyenne | WY | 82003 |
| MA - Minerals LLC | P.O. Box 3759 | Manhattan Beach | CA | 90266 |
| Mable O. Gustafson | Unknown Address | | | |
| Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 |
| Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 |
| Mahegge, LLC | P.O. Box 1416 | Mills | WY | 82644 |
| Malm Ranch Company | 6360 State Highway 216 | Albin | WY | 82050 |
| Manuel Blanco, IIII | Unknown Address | | | |
| MAP2009-OK c/o MAP Royalty, Inc. | 101 North Robinson Avenue, Suite 1000 | Oklahoma City | OK | 73102 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Marcia Lea Leastman | 4845 E. Adams Avenue | Carpenter | WY | 82054 |
| Marie E. Bachofer | 4643 Road 206 | Carpenter | WY | 82054 |
| Mariemont Properties, Inc | 3429 Southwestern Boulevard | Dallas | TX | 75225 |
| Mariland N. Gourley | 1400 North Rocking Horse Lane | Benson | AZ | 85602 |
| Marilyn K. Machay c/o Marilyn K. Detillion | 7004 Denise Road | Cheyenne | WY | 82009 |
| Marion E. Estes & William A. Estes, wh | 575 Long Lane | Casper | WY | 82609 |
| Marion O. Reeder, Trustee of the Marion O. Reeder Revocable Trust of 06-29-2004 | 4100 Road 205 | Carpenter | WY | 82054 |
| Marjorie Louise Faris Revocable Living Trust dated March 21, 2003 Marjorie Louise Faris as Trustee | 1506 Willow Street | San Diego | CA | 92106 |
| Mark and Karen R. Jenkins | 20030 WCR 33 | LaSalle | CO | 80645 |
| Mark C. and Laura E. Anzman, Co-Trustees of the Mark and Laura Anzman Living Trust, dated 5/8/2013 | 4655 County Road 207 | Carpenter | WY | 82054 |
| Mark E. Goehring and Karen J. Goehring | 336 N 1st | Carpenter | WY | 82054 |
| Mark Jenkins | 20030 WCR 33 | LaSalle | CO | 50645 |
| Mark Jenkins and Karen R. Jenkins | 11776 County Road 42 | Platteville | CO | 80651 |
| Mark Klingseisen | 2305A Westlake Drive | Austin | TX | 78746 |
| Mark R. Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 |
| Mark R. Stagg, life estate with remaindermen being his children Kristine Stagg, Josephine Stagg, Jacqueline Stagg, Jeannette Stagg and Julianne Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 |
| Mark Strader | 14932 Turn Bridge Drive | Frisco | TX | 75035 |
| Mark T. Cox, III and Elizabeth J. Cox, husband and wife | P.O. Box 47 | Cheyenne | WY | 82009 |
| Mark Worthington, Marcus Stanton Worthington aka Mark S. Worthington aka Marcus Stanton Walterstein | 1622 Ora Drive | Napa | CA | 94559 |
| Martin Jacob Miller | Unknown Address | | | |
| Martin Wissner, Trustee, and his successor in trust, under the Martin Wissner Living Trust, dated 5/31/2019, for the benefit of Martin Wissner and his heirs | 620 Road 146 | Carpenter | WY | 82054 |
| Marvin K. Stuart and Larita P. Stuart | 326 2nd St | Carpenter | WY | 82054 |
| Mary Christine Dorr and Susan Lee Snyder | Unknown Address | | | |
| Mary Lou King and Austin Dale King | P.O. Box 476 | Kellogg | ID | 83837 |
| Mary Maxine Soppe | 504 Road 148 | Carpenter | WY | 82054 |
| Mary Soppe | 5145 Clifford Avenue | Las Cruces | NM | 88012 |
| Maryl Betzwiser | 6369 Whitetail Ridge Court | Yorkville | IL | 60560 |
| Matthew Witherell and Kristin L. Witherell, JT | 4 Oxford Drive | Rogers | AR | 72758 |
| Maureen J. Shandera, Trustee of the Maureen J. Shandera Revocable Trust, dated 5/20/1998 | 5192 Road 207 | Carpenter | WY | 82054 |
| Maureen T. Moore | 4511 Buggy Road | Carpenter | WY | 82054 |
| Max E. True and Judy V. True | 4625 County Road 206 | Carpenter | WY | 82054 |
| Max Exploration, LLC | P.O. Box 9287 | Salt Lake City | UT | 84109 |
| Maxine B. Morgan | 8310 Heather Avenue | Eden Prairie | MN | 55347 |
| Maxine Soppe | P.O. Box 2778 | Cheyenne | WY | 82003 |
| Maxine Soppe | 504 Road 148 | Carpenter | WY | 82054 |
| McClintock & Nikoloric, LLC, BOKF, NA dba Colorado State Bank and Trust, Agent | P.O. Box 3499 | Tulsa | OK | 74101 |
| McCulliss Oil & Gas, Inc. | P.O. Box 221515 | Denver | CO | 80222 |
| McCulliss Resources Co., Inc. | P.O. Box 3248 | Littleton | CO | 80161 |
| McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 |
| Meridian Trust Federal Credit Union | P.O. Box 548 | Cheyenne | WY | 82003 |
| Merlyn Charles Faris | Unknown Address | | | |
| Merritt Lacy | 12733 W. Columbine Drive | El Mirage | AZ | 85335 |
| Michael B. Farris, a single man | P.O. Box 751 | Byers | CO | 80103 |
| Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 |
| Michael D. Konig and Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 |
| Michael D. Konig and Tena M. Konig | 58710 County Road 81 | Grover | CO | 80729 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Michael E. Cherry | 49273 295th | Genoa | NE | 68640 |
| Michael L. Dykes, as Trustee of The Michael L. Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 |
| Michael L. Oberwise | 3656 Red Baron Drive | Colorado Springs | CO | 80911 |
| Michael R. Calaway and Vickie L. Hintze | 4487 Teepee Road | Carpenter | WY | 82054 |
| Michael Schreiner, Successor Trustee of the Lois M. Schreiner Trust Agreement, dated 7/25/2006 | 416 Cody | Cheyenne | WY | 82009 |
| Michael Soppe | Unknown Address | | | |
| Michael Sullivan | P.O. Box 1054 | Mesquite | NV | 89024 |
| Michael W. and Dorothy M. Anthony | 595 County Road 143 | Carpenter | WY | 82054 |
| Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 |
| Mike Poelma and Caroline Poelma, Trustees of the Mike Poelma Living Trust dated 08-17-2011 and the Caroline Poelma Living Trust dated 08-17-2011 | 5296 Road 202 | Carpenter | WY | 82054 |
| Mildred Elizabeth Hewitt Bunnell | 1901 Howell Avenue | Worland | WY | 82401 |
| Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 |
| Misty Tinney & Roy V. Beaver, Jr. | Unknown Address | | | |
| Mitsuo Fuse | 14901 Quorum Drive, # 800 | Dallas | TX | 75254 |
| Moondance Minerals LP | P.O. Box 8445 | Denver | CO | 80201 |
| Morgan Jane Eastman-Lorenz | P.O. Box 1863 | Lihue | HI | 96766 |
| Mountain States Telephone and Telegraph Company | Unknown Address | | | |
| Mountaintop Minerals | 370 17th St., Ste 5200 | Denver | CO | 80202 |
| Nancy L. Flynn, Trustee of the Nancy L. Flynn Revocable Trust under agreement dated April 2, 2009, as amended and restated | P.O. Box 289 | Cheyenne | WY | 82009 |
| Natalie Shea Faber-Padmos | 263 River Vlley Road, #06-17 | Singapore | | 238309 |
| Neal Brent Faber | 3504 A Cannon Street | Twentynine Palms | CA | 29910 |
| New West Bank | 55 S Elm Avenue | Eaton | CO | 80615 |
| NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 |
| NG Resources, LLC | 9896 Clairton Way | Highlands Ranch | CO | 80126 |
| Nicole and Richard Lorh | 4507 Teepee Road | Carpenter | WY | 82054 |
| Noble Energy, Inc. | 1625 Broadway, Suite 2200 | Denver | CO | 80202 |
| Norman Harada | Unknown Address | | | |
| Norwest Bank Colorado, NA | 1740 Broadway | Denver | CO | 80274 |
| O S Property Development | 881 Ocean Drive, Casa De; Mar, Apartment 6G | Key Biscayne | FL | 33149 |
| Occidental Petroleum Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 |
| Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 |
| OG Resources, Inc. | Unknown Address | | | |
| OKSA Minerals, LP | 5111 Broadway | San Antonio | TX | 78209 |
| Old West Tours | 601 16th St., Suite C-153 | Golden | CO | 80401 |
| ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 |
| OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 |
| Oneonta Resources, LLC | 5228 Lonetree Drive | Loveland | CO | 80537 |
| Oscar E. Orozco and Michelle M. Orozco | 4807 Road 205 | Carpenter | WY | 82054 |
| Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 |
| Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 |
| Overland Energy Partners Fund II, LLC | 700 17th Street, Suite 900 | Denver | CO | 80202 |
| Overland Energy Partners I, LLC | 518 17th Street, #1005 | Denver | CO | 80202 |
| Oxford Exploration, LLC | 450 East 17th Avenue Suite 320 | Denver | CO | 80203 |
| Oxford Exploration, LLC | 4200 E. 8th Ave., Suite 102 | Denver | CO | 80220 |
| Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 |
| Pamela H. Wilson | 644 S. Griffith Park Dr. | Burbank | CA | 91506 |
| Pamela J. Burgener | 19 Nightingale Circle | Camargo | IL | 61919 |
| Patricia A and Peter C. Gassner, Jr. | 4567 County Road 207 | Carpenter | WY | 82054 |
| Patricia Hammond | Unknown Address | | | |
| Patricia Pico | 14438 Kingston Cove Lane | Houston | TX | 77077 |
| Patricia R. Walder-Christner | 6907 Willshire Blvd. | Cheyenne | WY | 82009 |
| Patrick M. Goodwine | 240 Road 143 | Carpenter | WY | 82054 |
| Patrick Rehwinkel | 13500 Road W | Weldona | CO | 80653 |
| Paul Arthur Auclair | 4859 Road 203 | Carpenter | WY | 82054 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Paul C. Mclaury | 300 E. Prosser Rd., Space 17 | Cheyenne | WY | 82007 |
| Paul M. Gonzales and Erin M. Gonzales | 4821 Main Ave. | Carpenter | WY | 82054 |
| Paula Marie Yarger | 4908 F.M. 879 | Palmer | TX | 75152 |
| Pawnee Butte Royalties, LLC | P.O. Box 4631 | Englewood | CO | 80155 |
| Pearlene Hawkins | 470A 2nd St. SW | Albuquerque | NM | 87105 |
| Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 |
| Peter Rehwinkel | 13500 Road W | Weldona | CO | 80653 |
| Phil Kiner and Marsha Kiner, husband and wife | 8225 Arrow Wood Lane | Cheyenne | WY | 82009 |
| Philip V. Breeden | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 |
| Phillip and Rudy Breeden | Unknown Address | | | |
| Phillip M. Brandt and Lorraine S. Brandt | 3153 Bluff Place | Cheyenne | WY | 82009 |
| Phillip V. Breeden Revocable Trust Dated December 13, 2013 | 90 County Road 143 | Carpenter | WY | 82054 |
| Pine Chalet Properties, LLC | 4022 E. 9th Street | Cheyenne | WY | 82001 |
| Platte River Energy, LLC | 852 Broadway, Suite 300 | Denver | CO | 80203 |
| Platte Valley Ag Credit Co. | P.O. Box 790 | Torrington | WY | 82240 |
| Platte Valley Bank | 421 Vandehei Avenue | Cheyenne | WY | 82009-6103 |
| Platte Valley Energy, LLC | 852 Broadway, Suite 300 | Denver | CO | 80203 |
| Preston Real Estate, LLC | 11904 Arbor Street, Suite 200 | Omaha | NE | 68114 |
| Principle Energy, L.L.C. | P.O. Box 2228 | Houston | TX | 77252 |
| Prism Energy, LLC | 4585 S. Taft Way | Morrison | CO | 80465 |
| Production Credit Association of the Midlands | P.O. Box J | Torrington | WY | 82240 |
| Proved Reserves, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 |
| Provident Trust Group, LLC as custodian FBO Dennis J. Kulonda Traditional IRA 180901668 | 8880 Sunset Road, Suite 250 | Las Vegas | NV | 89148 |
| Quicken Loans, LLC | 1050 Woodward Avenue | Detroit | MI | 48226-1906 |
| R. K. Pinson & Associates, LLC | 621 17th St., Suite 1555 | Denver | CO | 80293 |
| Raisa II, LLC | 1560 Broadway, Suite 250 | Denver | CO | 80202 |
| RAL Farms LLC, an Indiana Limited Liability Company | 13525 Bunker Hill Lane | St. Francisville | IL | 62460 |
| Ralf R. Filler and Loretta D. Filler, JT | 4715 Langford Lane | Wichita Falls | TX | 76310 |
| Ralph A. Bard, III | 59-425 Makana Road | Haleiwa | HI | 96712 |
| Ralph V. Kent | Unknown Address | | | |
| Rampike Resources, Ltd. | 730 17th Street, Suite 370 | Denver | CO | 80202 |
| Randy J. Peters | Unknown Address | | | |
| Randy Lynn and Victoria Lynn Ackerman | 6519 Kyle Avenue | Fort Collins | CO | 80525 |
| Raymond L. and Diana L. Martin | 4691 County Road 207 | Carpenter | WY | 82054 |
| Raymond Z. and Mildred E. Nolt | 535 Road 143 | Carpenter | WY | 82054 |
| RDMB Holdings, Inc | 3106 Druid Hill Drive | Des Moines | IA | 50315 |
| Rearden Minerals, LLC | 5914 W. Courtyard Drive | Austin | TX | 78730 |
| Red Baldy Ranch | 785 Road 140 | Carpenter | WY | 82054 |
| Red Harlan Royalties, LTD. | P.O. Box 670766 | Dallas | TX | 75367 |
| Reese Burnett and Hannah Burnett | 4840 Adams Ave. | Carpenter | WY | 82054 |
| Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 |
| Renegade Exploration, LLC | 1625 Broadway, Suite 830 | Denver | CO | 80202 |
| Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 |
| Richard B. Juenemann Revocable Trust Dated 7/18/2007, Richard B. Junemann, Trustee | 32768 220th Street | Sanborn | MN | 56083 |
| Richard Breeden | Unknown Address | | | |
| Richard Jesse | 3120 Carefree Highway 1538 | Phoenix | AZ | 85086 |
| Richard Leigh Faris | 431 Camino De Grato | Sparks | NV | 89441 |
| Richard Philip and Leanne Vannaman | 3337 Alexander Avenue | Cheyenne | WY | 82001 |
| Richard R. Whited Living Trust | 3670 Columbia Falls Stage | Columbia Falls | MT | 59912 |
| Riverstone Credit Management Cortland Capital Market Services, LLC | 225 West Washington Street 21st Floor | Chicago | IL | 60606 |
| Roaring Fork Midstream LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Robert E. Dettle and Rosalie T. Dettle Living Trust Dated 2/29/1980, Robert E. Dettle, Trustee | 1101 Water Street | Santa Cruz | CA | 95062 |
| Robert Gin and Rebekah Tan, Trustees of The Tan-Gin Family Trust, dated 9/1/2004 | 2568 West Overton Ridge Place | Tucson | AZ | 85742 |
| Robert I Canvarl Jr. | 6237 Ella Lee Lane | Houston | TX | 77057 |
| Robert M. Roof, Jr. and Sheala Roof | 390 Road 146 | Carpenter | WY | 82054 |
| Robert P. Dykes, as Trustee of The Robert P. Dykes Revocable Trust, dated 10/14/2011 | P.O. Box 260498 | Lakewood | CO | 80226 |
| Robert P. Korber Revocable Trust | 1725 Eagle Drive | Cheyenne | WY | 82009 |
| Roberta Lee May | 1251 Road 7 | Pine Bluffs | WY | 82082 |
| Rocket Mortgage, LLC fka Quicken Loans | 1050 Woodward Avenue | Detroit | MI | 48226-1906 |
| Rodella Vergamini and John Vergamini, TIC | 146 Vine Street | Council Bluffs | IA | 51503 |
| Rodney E. and Sylvia M. Girmus | 7067 Road 47F | Torrington | WY | 82240 |
| Roger G. Bunnell | 612 Sweetwater Avenue | Alliance | NE | 69301 |
| Roger Jewell | 4853 Monroe Ave | Carpenter | WY | 82054 |
| Roger N. and Eddy Linda Stearns | 4539 Buggy Road | Carpenter | WY | 82054 |
| Roger West Stanton, heir of Marcus A.W. Stanton, heir of Janet L. Stanton, Heir of Harlett Isabel Stanton | P.O. Box 3972 | Chico | CA | 95927 |
| Ronald D. and D Anna L. Catterson | 384 Road 148 | Carpenter | WY | 82054 |
| Ronald E. Poelma | 8351 Buckboard Road | Cheyenne | WY | 82009 |
| Ronald E. Poelma, Trustee under the Ronald E. Poelma Living Trust, u/a dated 06-19-2019 | 8351 Buckboard Road | Cheyenne | WY | 82009 |
| Rory G. Owens | 220 Chapel Hill Drive | Prosper | TX | 75078 |
| Roseshell A. Ward | Unknown Address | | | |
| Ross M. Taylor | 34750 Bachelor Flat Road | St. Helens | OR | 97051 |
| Roy F. and Barbara J. Young | 4820 Road 214 | Burns | WY | 82053 |
| Roy V. and Linda L. Beaver | 1104 Maddison Avenue | Cheyenne | WY | 82001 |
| RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 |
| Ruby Pearl True | Unknown Address | | | |
| Ruby Resources, LLC | 1530 P B Ln # 3592 | Wichita Falls | TX | 76302-2612 |
| Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 |
| Russell D. Matz and Bettyanne M. Haines | 4831 Monroe Avenue | Carpenter | WY | 82054 |
| Russell Mosier c/o Mark and Karen Jenkins | 11776 County Road 42 | Platteville | CO | 80651 |
| Ruth Enfield Edgar | Unknown Address | | | |
| Ruth M. and John P. Rome | 6516 Hedge Lane Terrace, Apt. # 106 | Shawnee | KS | 66226 |
| Ruth V. Willoughby | 215 South Third Avenue | Casper | WY | 82601 |
| Ryan F. and Vicki M. Nelson | 2070 Franklin Street | Laramie | WY | 82070 |
| SAG Ag, LLC | 58710 County Road 81 | Grover | CO | 80729 |
| Sage Farms, LLC | 1595 Tanaka Drive | Erie | CO | 80516 |
| Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 |
| Sandra A. Meyers | Unknown Address | | | |
| Sandra Ann Anthony | 6401 Ohio Drive, Apt. 1104 | Plano | TX | 75024 |
| Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 |
| Scott D. Rohrbouck | 571 Hourglass Court | Loveland | CO | 80537 |
| Scott Morgan and Denise Morgan | 312 2nd St. | Carpenter | WY | 82054 |
| Scott Thums and Elizabeth Thums | P.O. Box 372 | Carpenter | WY | 82054 |
| Scout Partners, LLC | P.O. Box 1348 | Edmond | OK | 73083-1348 |
| Shandera3, LLC | 3733 Gunsmoke Road | Cheyenne | WY | 82001 |
| Sharon E. Hayes Revocable Trust | 18821 Freemont Avenue North | Shoreline | WA | 98133 |
| Sharon K. Miller and Brent L (Nidelkoff) Piscitello | 1722 Cheshire Drive | Cheyenne | WY | 82001 |
| Sharon McDonald | 107 Roger's Lane, CR 302 | Durango | CO | 81303 |
| Shawn P. and Brandi Halls | 1708 County Road 136 | Cheyenne | WY | 82009 |
| Sherry Cox Dupee | 105 Fair Acres Road | Oxford | England | OX4 - 1 TQ |
| Sherryl E. Faris | 2238 Peru Road | Peru | IA | 50222 |
| Shirley Helen Rose | 3064 Grier Blvd. | Cheyenne | WY | 82001 |
| Shirley Melton | 5052 Archer Lane North | Plymouth | MN | 55446 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Shirley Price | 3064 Grier Blvd. | Cheyenne | WY | 82001 |
| Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 |
| Sidwell Ranch, LLC | 392 County Road 145 | Carpenter | WY | 82054 |
| Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 |
| Simmons Bank | 3001 Brighton Boulevard, Suite 718 | Denver | CO | 80216 |
| Sisters of St. Francis | 5314 N. Columbine Road | Denver | CO | 80221 |
| Smith & Jones, LLC | 6102 East Hwy 30 | Cheyenne | WY | 82001 |
| Smith and Jones, LLC c/o Jimmy V. Jones | 678 Sand Castle Way | Mesquite | NV | 89027 |
| Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 |
| Springfield Oil Company | 27619 Brook Drive | Hot Springs | SD | 57747 |
| SSALJD Investment Group LLC | P.O. Box 280969 | Lakewood | CO | 80228-0969 |
| St Peters Church | 316 4th Street | Carpenter | WY | 82054 |
| Stafford Investments, LTD. | P.O. Box 11115 | Midland | TX | 79702-1115 |
| Stanley D. and Jennifer L. Baer | 4644 Road 204 | Carpenter | WY | 82054 |
| State of Wyoming<br>Office of State Lands & Investments | Herschler Building<br>122 W. 25th Street - W103 | Cheyenne | WY | 82002 |
| Stephen Deaver aka The Reverend Stephen Deaver | 615 W. 42nd Street | Scottsbluff | NO | 69361 |
| Stephen Gifford Stanton, aka Stephen G. Stanton | 56 Napa Valley Club Circle | Napa | CA | 94558 |
| SunTrust Mortgage, Inc. | 901 Semmens Avenue | Richmond | VA | 23224 |
| Superior Oilfield Services Co., LTD | P.O. Box 336356 | Greeley | CO | 80633 |
| Susan K. Breeden | 2702 19th Street Drive, #17 | Greeley | CO | 80634 |
| Susan Olson-Miller | Unknown Address | | | |
| Susie Breeden | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 |
| Suzanne Beverly Hart | c/o Diane Deutsch<br>848 E. Windsor Dr. | Gilbert | AZ | 85296 |
| Swanson Production Company | 339 Indian Paintbrush Drive | Golden | CO | 80401 |
| Syliva J. Parvin and Robert A. Parvin | P.O. Box 144 | Rock River | WY | 82083 |
| T. F. Hodge | 1605 Continental Bank Building | Fort Worth | TX | 76102 |
| T.E. McClintock T/W fbo Mary M. Swift, U.S. Bank, N.A., Trustee | P.O. Box 17532 | Denver | CO | 80217 |
| T10 Unison Site Management LLC | P.O. Box 1951 | Frederick | MD | 21702 |
| Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 |
| Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 |
| Tammy J. Tenley | 336 Silas Court | Spring Hill | FL | 34609 |
| TAPS I Energy, LLC | 1001 Farmington Avenue, Suite 200 | West Hartford | CT | 06107 |
| TARH E&P Holdings, L.P. | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 |
| Ted A. Bunnell, aka Teddy Alan Bunnell | 203 Jim Street | Billings | MT | 59101 |
| Ted N. Steffen Trust (or his successor) of a Trust created on 2/3/2003 | 2404 Barret Hill Road | Louisville | KY | 40205 |
| Terry L. Nachtman | 581 Road 143 | Carpenter | WY | 82054 |
| Terry Lee Faber | 2901 Hermosa Court | Grand Junction | CO | 81504 |
| Texas American Resources Co. | 410 17th Street, Suite 1610 | Denver | CO | 80202 |
| The Bluffs, LLC | 392 County Road 145 | Carpenter | WY | 82054 |
| The Cheryl Ann Jeffers Living Trust u/d/a dated April 19, 2019, Cheryl Ann Jeffers as Trustee | P.O. Box 454 | Carpenter | WY | 82054 |
| The Federal Land Bank of Omaha | 206 S. 19th St. | Omaha | NE | 68102 |
| The Gordon Malm Revocable Trust dated 02-20-1998 | P.O. Box 55 | Albin | WY | 82050 |
| The Greg & Nancy Vance Family Limited Partnership<br>c/o Production Gathering Company, LP | 8080 N. Central Expressway, Suite 1090 | Dallas | TX | 75206 |
| The J. Christopher Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 |
| The Jacobson Family Trust UA Dated 1/5/1994, Elaine Virginia Jacobson, Trustee | 1864 Lime Tree Lane | Mountain View | CA | 94040 |
| The Lutheran Home | 530 South 26th Street | Omaha | NE | 68105 |
| The Michael L. Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 |

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| The Mountain States Telephone and Telegraph Company | 931 14th Street | Denver | CO | 80202 |
| The Oswald Family Irrevocable Trust | 7200 S. Alton Way, Suite B-250 | Centennial | CO | 80112 |
| The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083 |
| The Ridge, LLC | 392 County Road 145 | Carpenter | WY | 82054 |
| The State Highway Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 |
| The te Velde Family LLLP | 7619 Road 19 | Fort Lupton | CO | 80621 |
| The Transportation Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 |
| Thomas A. Alico | 410 Waterside Lane | Nokomis | FL | 34275 |
| Thomas E. Shows and Edna M. Shows, JT | 150 Tom Shows Road | Seminary | MS | 39479 |
| Thomas E. Werlin | 62 Legend Lane | Houston | TX | 77024 |
| Thomas Harrower, Jr. and Lillian Harrower | 8603 Powderhouse Road | Cheyenne | WY | 82009 |
| Thomas J. Buckley | 2310 Royal Oaks Drive | Mansfield | TX | 76063 |
| Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 |
| Thomas S. Harrower, Jr. | 8603 Powderhouse Road | Cheyenne | WY | 82009 |
| Thomas V. Breeden | 565 S. Parfet | Lakewood | CO | 80226 |
| Thomas W. Stagg | 1309 Ironwood Street | Boulder City | NV | 89004 |
| Thomas Winter Kirchgessner | 10404 Griffon Drive NW | Albuquerque | NM | 87114 |
| Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 |
| Tippy C. Costello | 1209 W. 22nd Street | Cheyenne | WY | 82001 |
| Todd Alan Martin and Sydnee Marie Martin as Co-Trustees of the Todd Alan Martin and Sydnee Marie Martin Marital Trust u/t/a dated 11-21-2019 | 169 County Road 148 | Carpenter | WY | 82054 |
| Todd D. Harlan | 319 Walnut St. | Hickman | NE | 68372 |
| Tom Bunnell, aka Tommy Lynn Bunnell | 821 Russell Avenue | Worland | WY | 82401 |
| Tommarr, LLC | 108 Nickerson Lane | Romeo | ME | 04963 |
| Top Notch Land Services, Inc. | P.O. Box 328 | Kimball | NE | 69145 |
| Tracey J. Wrobel | 420 Wedgewood Circle | Lake in the Hills | IL | 60156 |
| Trading River Trading Company | P.O. Box 260498 | Lakewood | CO | 80226 |
| Travis and Christy Wilson | 4661 Road 206 | Carpenter | WY | 82054 |
| Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 |
| Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 |
| TRP Minerals, LLC | 4545 Post Oak Place, Suite 240 | Houston | TX | 70277 |
| U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 |
| U.S. Bank Trust Company, N.A. | 425 Walnut Street, 6th Floor | Cincinnati | OH | 45202 |
| U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 |
| U.S. Bank, National Association | Attention Global Corporation<br>950 17th Street | Denver | CO | 80202 |
| U.S. Bank, National Association | Corporate Trust Services<br>60 Livingston Ave<br>EP-MN-WS3C | St. Paul | MN | 55107 |
| U.S. Bank, National Association | Corporate Trust Services<br>40 Pearl Street NW, Suite 838 | Grand Rapids | MI | 49503 |
| U.S. National Bank NA, Trustee of the T. E. McClintock Mineral Trust c/o US Bank | P.O. Box 17532 | Denver | CO | 80217 |
| UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 |
| Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 |
| United States of America / Bureau of Land Management | 5353 Yellowstone Road | Cheyenne | WY | 82009 |
| United Wholesale Mortgage, LLC | 585 South Boulevard E | Pontiac | MI | 48341 |
| UniWyo Federal Credit Union | 2020 E. Grand Avenue, Suite 100 | Laramie | WY | 82070 |
| US West Communications, Inc. | 7800 East Orchard Suite 480 | Englewood | CO | 80111 |
| Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 |
| Verdad Resources, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 |
| Victoria A. Ladd | 608 Wentworth Drive | McKinney | TX | 75070 |
| Vincent Kunderman | 17319 Hilltop Ridge Drive | Eureka | MO | 63025 |
| Virginia G. Newman | Unknown Address | | | |
| Wake Energy, LLC | P.O. Box 5074 | Edmond | OK | 73083 |
| Wake Family Living Trust Dated 1/5/1994, Harold E. Wake, Trustee | 1013 Oakwook Circle | Carmel | CA | 93923 |
| Walter L. Farrington, III | P.O. Box 640766 | Dallas | TX | 75367 |
| Wanda Darlene Hughes | 480 W. 10th Avenue | Kettle Falls | WA | 99141 |

Notification 43N-72W-36
Campbell County, Wyoming

| Organization | Address 1 | City | Region | Postal Code |
|---|---|---|---|---|
| Ware Family, LLC c/o Yvonne L. Ware | P.O. Box 423 | Carpenter | WY | 82054 |
| Warren Lawrence and Nanch Kay Lawrence, JT | 2535 South Newton Street | Denver | CO | 80219 |
| Water Oaks Capital Minerals, LLC | 2101 Cedar Springs, Suite 1600 | Dallas | TX | 75201 |
| Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 |
| Wells Fargo Bank , N.A. | 1700 Lincoln Street<br>Third Floor MAC C7300-003 | Denver | CO | 80203 |
| Wells Fargo Bank , N.A. | P.O. Box 11701 | Newark | NJ | 07101-4701 |
| Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 |
| Wesley J. Faris | 1120 Marcy Street | Ottawa | IL | 61350 |
| Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 |
| Western Minnesota Power Agency | 220 South 6th St., Suite 1300 | Minneapolis | MN | 55402 |
| Western Vistas FCU | 3207 Sparks Road | Cheyenne | WY | 82001 |
| Westland Holdings, Inc. | P.O. Box 653 | Cheyenne | WY | 82003 |
| Weston Eugene Cochran | 609 Ash Street | Fort Morgan | CO | 80701 |
| William B. Wilsted and Leanne C. Wilsted | 7378 Augusta Drive | Boulder | CO | 80301 |
| William Collicott, as PR for the Estate of Melvin L. Collicott | Unknown Address | | | |
| William E. Hill and Jan C. Hill, husband and wife | 91 Wood Road | Centereach | NY | 11720 |
| William J. Breeden | 3630 Foxcroft Road | Cheyenne | WY | 82001 |
| William J. Breeden, Thomas J. Breeden and Karen Breeden | 3630 Foxcroft Road | Cheyenne | WY | 82001 |
| Winnie L. Stephan as Trustee of the Winnie L. Stephan Revocable Trust, dtd December 8, 2011 | P.O. Box 692 | Cheyenne | WY | 82003 |
| WK Land Company | 911 Kimbark St. | Longmont | CO | 80501 |
| Wolf Resources, LLC | 621 17th St., Ste 1601 | Denver | CO | 80293 |
| Wolfhawk Energy Holdings, LLC | 999 18th Street, Suite 16508 | Denver | CO | 80202 |
| WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 |
| WOV, LLC | 1120 Lincoln St. Suite 908 | Denver | CO | 80203 |
| WYDJ Energy LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 |
| WYDJ Investments I LLC | 1120 Lincoln St. Suite 908 | Denver | CO | 80203 |
| WYDJ Investments I LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 |
| WYDJ ORI Investments I, LLC | P.O. Box 460868 | Denver | CO | 80246 |
| WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 |
| WyHy Federal Credit Union | 1715 Stillwater Avenue | Cheyenne | WY | 82009 |
| WYOCO Royalty Partners, LLC, a Colorado limited liability company | 410 17th Street, Suite 1150 | Denver | CO | 80202 |
| Wyoming Bank & Trust | 5827 Yellowstone Road | Cheyenne | WY | 82009 |
| Wyoming Community Development Authority | 155 North Beech | Casper | WY | 82602 |
| Wyoming Western Oil | P.O. Box 458 | Pine Bluffs | WY | 82082 |
| Zachary Gleit, Trustee of the Roberta Gleit Revocable Trust dated February 24, 2018 | 4301 North Ocean Boulevard | Boca Raton | FL | 33431 |
| Zachary Gleit, Trustee of the Roberta Gleit Revocable Trust dated February 24, 2018 | 755 West End Ave. #6C | New York | NY | 10025 |
| Zandra A. Harper | P.O. Box 366 | Carpenter | WY | 82054 |
| Zarephath LLC | 4520 14th Street Drive | Greeley | CO | 80524 |
| Zora N. Montgomery | 816 South 216th Street, T311 | Des Moines | WA | 98198 |

AD# 465970

# Exhibit "C"

**Notice of Geologic Sequestration Project Underground Injection Control Permit Application Submission Wyoming Department of Environmental Quality**

In accordance with Wyoming Statute, 35-11-313(f)(ii)(N), notice is being provided to inform the public that Tallgrass High Plains Carbon Storage, LLC. has submitted a UIC Class VI (Carbon Sequestration) Permit Application to the Wyoming Department of Environmental Quality for issuance of a permit for the Spirea I-1 (Eastern Wyoming Sequestration Hub) located in the SW ¼ NW ¼ Section No. 34, Township 13N, Range 63W of the 6th Principal Meridian, Laramie County.

Prior to permit issuance, WDEQ will hold a 60-day public comment period followed by a public hearing. A copy of the permit application may be accessed at https://deq.wyoming.gov/water-quality/groundwater/uic/class-vi/. If you have questions, please contact Lily Barkau, Groundwater Section Manager, Water Quality Division, Wyoming Department of Environmental Quality at 307-777-7072 or lily.barkau@wyo.gov. Para Española, visite nuestro sitio web deq.wyoming.gov.

January 8, 2024
NO. 465970

# APPENDIX K—NOTIFICATION LIST

**NOTIFICATION LIST**
**Spirea**
**Laramie County, Wyoming**
**Weld County, Colorado**

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| T12N - R62W<br>Sec. 6: Lots 1, 2 , S2NE, less fractional part of Lot 2 & S2NE | James L. Rodebaugh & Maria J. Rodebaugh, hw | 4875 County Road 203 | Carpenter | WY | 82054 | SI / MI |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| T12N - R62W<br>Sec. 6: Fractional Part of Lot 2 and S2NE | Paul Arthur Auclair | 4859 Road 203 | Carpenter | WY | 82054 | SI / MI |
| | David John Leastman II | 320 5th Street | Carpenter | WY | 82054 | SI |
| | David Brookens | 556 Central Avenue | Beach | ND | 58621 | SI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | TARH E&P Holdings, L.P. | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1100 | Denver | CO | 80202 | ORRI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Mark Klingseisen | 2305A Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5815 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T12N - R62W<br>Sec. 6: Lots 3, 4, 5, SENW | Abram Landis Derstine & Annette Marie Destine, HW, TBE | 215 County Road 148 | Carpenter | WY | 82054 | SI |
| | Patrick Rehwinkel | 13500 Road W | Weldona | CO | 80653 | MI |
| | Peter Rehwinkel | 13500 Road W | Weldona | CO | 80653 | MI |
| | Jonna Rehwinkel Lewis | 13500 Road W | Weldona | CO | 80653 | MI |
| | Heidi Rehwinkel Moore | 13500 Road W | Weldona | CO | 80653 | MI |
| | David M. Jesse | 51 Eldred | Bedford | OH | 44146 | MI |
| | Richard Jesse | 3120 Carefree Highway 1538 | Phoenix | AZ | 85086 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | TARH E&P Holdings, L.P. | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1100 | Denver | CO | 80202 | ORRI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Julian Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Mark Klingseisen | 2305A Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5815 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | US West Communications, Inc. | 7800 East Orchard Suite 480 | Englewood | CO | 80111 | ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R62W<br>Sec. 6: Lots 6, 7, E2SW | Clayton Derstine & Sonya Derstine, hw | P.O. Box 358 | Carpenter | WY | 82054 | SI / MI |
| | Abram Landis Derstine & Annette Marie Destine, HW, TBE | 215 County Road 148 | Carpenter | WY | 82054 | SI |
| | Zandra A. Harper | P.O. Box 366 | Carpenter | WY | 82054 | SI |
| | Bill Barrett Corporation | 1099 18th Street, Suite 2300 | Denver | CO | 80202 | MI |
| | Marion E. Estes & William A. Estes, wh | 575 Long Lane | Casper | WY | 82609 | MI |
| | Elizabeth L. Willoughby & Robert F. Willoughby, wh | 142 Flagstaff Way | Buffalo | WY | 82834 | MI |
| | Ruth V. Willoughby | 215 South Third Avenue | Casper | WY | 82601 | MI |
| | Barry S. Farris & Gralyn J. Farris, hw | 1544 South Pitkin Circle | Aurora | CO | 80017 | MI |
| | Jeffrey B. Farris & Mary Ann Farris, hw | P.O. Box 751 | Byers | CO | 80103 | MI |
| | Michael B. Farris, a single man | P.O. Box 751 | Byers | CO | 80103 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Springfield Oil Company | 27619 Brook Drive | Hot Springs | SD | 57747 | WI |
| | TARH E&P Holdings, L.P. | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1100 | Denver | CO | 80202 | ORRI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Julian Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Mark Klingseisen | 2305A Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5815 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Blue Federal Credit Union | P.O. Box 3200 | Cheyenne | WY | 82003 | MTG |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R62W | Leo Smith and Janet Smith | 115 Road 153 | Carpenter | WY | 82054 | SI / MI |
| Sec. 6: SE | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | TARH E&P Holdings, L.P. | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1100 | Denver | CO | 80202 | ORRI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Julian Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Mark Klingseisen | 2305A Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5815 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | US West Communications, Inc. | 7800 East Orchard Suite 480 | Englewood | CO | 80111 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R62W | Leo Smith and Janet Smith | 115 Road 153 | Carpenter | WY | 82054 | SI |
| Sec. 7: NE | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| | BNSF Railway Company | 2650 Lou Menk Drive | Fort Worth | TX | 76131-2830 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W | Emmanuel Farm LLP | 220 Road 148 | Carpenter | WY | 82054 | SI |
| Sec. 7: Lots 1, 2, E2NW | Todd Alan Martin and Sydnee Marie Martin as Co-Trustees of the Todd Alan Martin and Sydnee Marie Martin Marital Trust u/t/a dated 11-21-2019 | 169 County Road 148 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Clear Creek Resource Partners | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W | Cindy I. Johnston, Trustee under the | 609 Artesian Road | Cheyenne | WY | 82007 | SI |
| Sec. 7: Lots 3, 4, E2SW | Mike Poelma and Caroline Poelma, Trustees of the Mike Poelma Living Trust dated 08-17-2011 and the Caroline Poelma Living Trust dated 08-17-2011 | 5296 Road 202 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Clear Creek Resource Partners | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W<br>Sec. 7: SE | Gilbert M. Weaver and Karen W. | 4829 Road 201 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Clear Creek Resource Partners | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| | BNSF Railway Company | 2650 Lou Menk Drive | Fort Worth | TX | 76131-2830 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W<br>Sec. 18: NE | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI / ROW |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | David Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Ann Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Ronald E. Poelma, Trustee under the Ronald E. Poelma Living Trust, u/a dated 06-19-2019 | 8351 Buckboard Road | Cheyenne | WY | 82009 | SI / MI |
| | Joseph J. Poelma and Patricia Poelma c/o Ronald E. Poelma | 8351 Buckboard Road | Cheyenne | WY | 82009 | MI |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| | Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 | MTG |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 1601 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W<br>Sec. 18: E2NW, N2SE | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI / ROW |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | David Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Ann Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Gilbert M. Weaver and Karen W. Weaver | 4829 Road 201 | Carpenter | WY | 82054 | SI |
| | Ronald E. Poelma | 8351 Buckboard Road | Cheyenne | WY | 82009 | MI |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| | Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 | MTG |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U S West Communications, Inc. | 1601 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R62W<br>Sec. 18: Lots 1, 2, 3, 4, E2SW, S2SE | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI / ROW |
| | Laramie Operating LLC, a Colorado limited liability company | 1120 Lincoln Street, Suite 1605 | Denver | CO | 80203 | WI |
| | Falcon Royalty & Investment Company, LLC | 215 West Oak Street, Suite 900 | Fort Collins | CO | 80521 | ORRI |
| | Lewis C. Camp & Lynelle Camp, as jts | 13500 Road W | Weldona | CO | 80653 | ORRI |
| | Kona Royalties, LLC | 7521 West 19th Street | Greeley | CO | 80634 | ORRI |
| | David Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Ann Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Arlen J. Hershberger & Lola M. Hershberger, as jts | 1561 Ivy | Denver | CO | 80220 | ORRI |
| | Anita Ruth Johnson c/o Barbara Duggan | P.O. Box 35 | Hereford | CO | 80732 | SI / MI |
| | Francis W. Blake | 5700 East CR 48 | Fort Collins | CO | 80524 | MI |
| | Francis W. Blake, Trustee of the Ettie P. Blake Living Trust, dated 08-15-1988 | 5700 East CR 48 | Fort Collins | CO | 80524 | MI |
| | WYOCO Royalty Partners, LLC, a Colorado limited liability company | 410 17th Street, Suite 1150 | Denver | CO | 80202 | MI |
| | Kathleen Eastman-Lorenz, Successor Trustee of the Michael Philip Lorenz Revocable Living Trust | P.O. Box 1863 | Lihue | HI | 96766 | MI |
| | Mark Jenkins and Karen R. Jenkins | 11776 County Road 42 | Platteville | CO | 80651 | MI |
| | Wolfhawk Energy Holdings, LLC | 999 18th Street, Suite 16508 | Denver | CO | 80202 | MI |
| | McClintock & Nikoloric, LLC, BOKF, NA dba Colorado State Bank and Trust, Agent | P.O. Box 3499 | Tulsa | OK | 74101 | MI |
| | T.E. McClintock T/W fbo Mary M. Swift, U.S. Bank, N.A., Trustee | P.O. Box 17532 | Denver | CO | 80217 | MI |
| | Mildred Elizabeth Hewitt Bunnell | 1901 Howell Avenue | Worland | WY | 82401 | MI |
| | Roger G. Bunnell | 612 Sweetwater Avenue | Alliance | NE | 69301 | MI |
| | Tom Bunnell, aka Tommy Lynn Bunnell | 821 Russell Avenue | Worland | WY | 82401 | MI |
| | Donald W. Bubar | 10408 Creighton Road | SW Fife Lake | MI | 49633 | MI |
| | Ted A. Bunnell, aka Teddy Alan Bunnell | 203 Jim Street | Billings | MT | 59101 | MI |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| | Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 | MTG |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | U S West Communications, Inc. | 1601 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T12N - R63W<br>Sec. 1: Lots 1-4, S2N2 | The Cheryl Ann Jeffers Living Trust u/d/a dated April 19, 2019, Cheryl Ann Jeffers as Trustee | P.O. Box 454 | Carpenter | WY | 82054 | SI / MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | ROW |
| | AT&T Mobility Corporation | 1025 Lenox Park Blvd. NE 3rd Floor | Atlanta | GA | 30319 | ROW |
| | Allen D. and April J. Kinnison | 274 Road 147 | Carpenter | WY | 82054 | SI / MI |
| | Kaiser-Francis Oil Company | P.O. Box 21468 | Tulsa | OK | 74121 | WI |
| | CBK Investments, LLC | P.O. Box 21468 | Tulsa | OK | 74121 | WI |
| | Verdad Resources, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 | WI |
| | CBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ORRI |
| | Wyoming Bank & Trust | 5827 Yellowstone Road | Cheyenne | WY | 82009 | MTG |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | T10 Unison Site Management LLC | P.O. Box 1951 | Frederick | MD | 21702 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T12N - R63W<br>Sec. 1: SW | Mariland N. Gourley | 1400 North Rocking Horse Lane | Benson | AZ | 85602 | SI |
| | Anadarko Land Corp., a Nebraska corporation, formerly Union Pacific Land Resources Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| T12N - R63W<br>Sec. 1: SE | The Cheryl Ann Jeffers Living Trust u/d/a dated April 19, 2019, Cheryl Ann Jeffers as Trustee | P.O. Box 454 | Carpenter | WY | 82054 | SI / MI |
| | Emmanuel Farm LLP | 220 Road 148 | Carpenter | WY | 82054 | SI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| T12N - R63W<br>Sec. 2: Lots 1, 2, 3, 4 , S2N2, SW | Grace Valley, LLC | P.O. Box 391 | Carpenter | WY | 82054 | SI |
| | Allen D. and April J. Kinnison | 274 Road 147 | Carpenter | WY | 82054 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Lester D. True, Trustee, or his successors in trust, under the Lester D. True Living Trust dated 1/17/2003 | 274 Road 147 | Carpenter | WY | 82054 | MI |
| | Covault Resources, LLC | 101 Cook St, Suite 3000 | Denver | CO | 80206 | MI |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| T12N - R63W<br>Sec. 2: SE | Michael D. Konig and Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 | MI |
| | Mark R. Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | David F. Stagg | 9609 239th Street North | Port Byron | IL | 61275 | MI |
| | LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 | MTG |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| T12N - R63W<br>Sec 3: Lots 1-4, S2N2, S2 | Grace Valley, LLC | P.O. Box 391 | Carpenter | WY | 82054 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Rearden Minerals, LLC | 5914 W. Courtyard Drive | Austin | TX | 78730 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Bill Barkley | 10115 Branding Iron Drive | Cheyenne | WY | 82009 | MI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Farmers Bank | P.O. Box 220 | Ault | CO | 80610 | MTG |
| T12N - R63W<br>Sec. 4: Lots 1-4, S2N2, S2 | Sidwell Ranch, LLC | 392 County Road 145 | Carpenter | WY | 82054 | SI / ROW |
| | Gordon Malm Revocable Trust | P.O. Box 55 | Albin | WY | 82050 | SI / MI |
| | Jerald F. Sidwell | 4481 Road 203 | Carpenter | WY | 82054 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Walter L. Farrington, III | P.O. Box 640766 | Dallas | TX | 75367 | MI |
| | Red Harlan Royalties, LTD. | P.O. Box 670766 | Dallas | TX | 75367 | MI |
| | Audie Hoke and Cherie R. Hoke | 2509 Crosstimbers Drive | College Station | TX | 77840 | MI |
| | Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 | MI |
| | MAP2009-OK c/o MAP Royalty, Inc. | 101 North Robinson Avenue, Suite 1000 | Oklahoma City | OK | 73102 | MI |
| | Albert H. Glassburn and Mary E. Glassburn, husband and wife | P.O. Box 755 | Jackson | WY | 83001 | MI |
| | Fossil Creek Land Company | P.O. Box 485 | Mustang | OK | 73064 | MI |
| | Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 | MI |
| | Charles W. and Patty N. Brown, LLC | 6408 Outabounds Court | Oklahoma City | OK | 73116 | MI |
| | The Bluffs, LLC | 392 County Road 145 | Carpenter | WY | 82054 | MI |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | The Ridge, LLC | 392 County Road 145 | Carpenter | WY | 82054 | MI |
| | Bold Resources, LLC | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Deborah L. Shepardson | 811 Heather Lane | Montrose | CO | 81401 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Kaiser-Francis Mid-Continent Limited Partnership | P.O. Box 2280 | Tulsa | OK | 74101 | WI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 | WI |
| | Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 | WI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Enerquest Oil & Gas, L.L.C. | 12368 Market Drive | Oklahoma City | OK | 73114 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | WI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Simmons Bank | 3001 Brighton Boulevard, Suite 718 | Denver | CO | 80216 | MTG |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Farmers & Merchants Bank of Colby | P.O. Box 797 | Colby | KS | 67701 | MTG |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| T12N - R63W<br>Sec. 5: Lots 1-4. S2N2, S2 | The Gordon Malm Revocable Trust dated 02-20-1998 | P.O. Box 55 | Albin | WY | 82050 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | Lost River Trading Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Red Harlan Royalties, LTD. | P.O. Box 670766 | Dallas | TX | 75367 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | U.S. Bank, National Association | Attention Global Corporation<br>950 17th Street | Denver | CO | 80202 | MTG |
| | U.S. Bank, National Association | Corporate Trust Services<br>60 Livingston Ave<br>EP-MN-WS3C | St. Paul | MN | 55107 | MTG |
| | U.S. Bank, National Association | Corporate Trust Services<br>40 Pearl Street NW, Suite 838 | Grand Rapids | MI | 49503 | MTG |
| | U.S. Bank Trust Company, N.A. | 425 Walnut Street, 6th Floor | Cincinnati | OH | 45202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | Basin Electric Power Cooperative | 1717 E. Interstate Avenue | Bismarck | ND | 58503 | ROW |
| | Western Minnesota Power Agency | 220 South 6th St., Suite 1300 | Minneapolis | MN | 55402 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| T12N - R63W<br>Sec. 6: Lots 1-5, SENW, S2NE | Fred L. Acheson and Diana K. Joint Revocable Trust | P.O. Box 220 | Hillsdale | WY | 82060 | SI / MI |
| | Cox Minerals LLC | 2812 1st Avenue North | Billings | MT | 59103 | MI |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | ORRI |
| | Sherry Cox Dupee | 105 Fair Acres Road | Oxford | England | OX4 - 1 TQ | MI |
| | ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 | MI |
| | Janice Ann Taylor aka Jan Taylor aka Janice A. Taylor | 636 E. Magnesium Rd. Apt C-111 | Spokane | WA | 99208 | MI |
| | LOR Capital I, LLC | 1120 Lincoln Street, Suite 1605 | Denver | CO | 80203 | WI |
| | Faith Partners Land Company, LLC | 4772 Tara Ct. | West Bloomfield | MI | 48323 | ORRI |
| | WYDJ ORI Investments I, LLC | P.O. Box 460868 | Denver | CO | 80246 | ORRI |
| | WYDJ Energy LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | WYDJ Investments I LLC | 1120 Lincoln St. Suite 908 | Denver | CO | 80203 | ORRI |
| | WOV, LLC | 1120 Lincoln St. Suite 908 | Denver | CO | 80203 | WI |
| | Kimberly T. Dunn | 2631 W. Dell Drive | Spokane | WA | 99208 | MI |
| | Ross M. Taylor | 34752 Bachelor Flat Road | St. Helens | OR | 97051 | MI |
| | Norman Harada | Unknown Address | | | | WI |
| | Kestrel Properties Corp. | P.O. Box 3972 | Morrison | CO | 80465 | ORRI |
| | Alice G. Tower | 2434 Rancho Road | Billings | MT | 59102 | MI |
| | E. Lee Tower | Box 1770 | Redlodge | MT | 59068 | MI |
| | Jill Jahn, aka Jill Tower aka Jill F. Tower | P.O. Box 156 | Fishtail | MT | 59222 | MI |
| | Keith Tower and Martha J. Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 | MI |
| T12N - R63W<br>Sec. 6: Lots 6, 7, E2SW, SE | Patrick M. Goodwine | 240 Road 143 | Carpenter | WY | 82054 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI / ROW |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | ROW |
| | Jimmie Dee Talkington | Box 224 | Hillsdale | WY | 82060 | MI |
| | Lela Sue Dennis | Box 6 | Lingle | WY | 82223 | MI |
| | Connie Faye Snyder | 8203 A Wyncote Rd | Lingle | WY | 82223 | MI |
| | Joann Soto | 3338 Vanvelzor #B | Cheyenne | WY | 82001 | MI |
| | Roger West Stanton, heir of Marcus A.W. Stanton, heir of Janet L. Stanton, Heir of Harlett Isabel Stanton | P.O. Box 3972 | Chico | CA | 95927 | MI |
| | Janet I. Stanton, a widow | 3086 Stadium Ave | Napa | CA | 94558 | MI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| | Simmons Bank | 3001 Brighton Boulevard, Suite 718 | Denver | CO | 80216 | MTG |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | WI |
| | Stephen Gifford Stanton, aka Stephen G. Stanton | 56 Napa Valley Club Circle | Napa | CA | 94558 | MI |
| | Mark Worthington, Marcus Stanton Worthington aka Mark S. Worthington aka Marcus Stanton Walterstein | 1622 Ora Drive | Napa | CA | 94559 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | James S. Worthington aka James Stanton Worthington aka Jim S. Worthington aka James Stanton Walterstein | 559 7th St. W | Sonoma | CA | 95476 | MI |
| | Frank Worthington aka Frank Walterstein, heir of Harriett Stanton Walterstein aka Harriett Stanton Worthington aka Harriett Stanton Gilleas, heir of Harlett Isabel Stanton | 1200 Mira Mar Ave. #931 | Medford | OR | 97504 | MI |
| T12N - R63W<br>Sec. 7: All | Phillip V. Breeden Revocable Trust Dated December 13, 2013 | 90 County Road 143 | Carpenter | WY | 82054 | SI / MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | MTG |
| | Clear Creek Fund I-B, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | MTG |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | WI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | MI |
| | Clear Creek Fund I-A, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Double Eagle Energy Rockies, LLC | 1401 Ballinger Street, Suite 203 | Fort Worth | TX | 76102 | WI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI / WI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Noble Energy, Inc. | 1625 Broadway, Suite 2200 | Denver | CO | 80202 | MTG |
| | Cirque Brennsee, LLC | 475 17th Street, Suite 1600 | Denver | CO | 80202 | WI |
| | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 | WI |
| | Jeanie M. Grogan | 613 SW Drive | Cheyenne | WY | 82007 | MI |
| | Katherine Tippy Castello aka K. Tippy Costello | 1209 W. 22nd Street | Cheyenne | WY | 82001 | MI |
| | James E. and Kina M. Costello Family Trust dated December 23, 1999 | 613 SW Drive | Cheyenne | WY | 82007 | MI |
| | Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| T12N - R63W<br>Sec. 8: All | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ORRI |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | Ardith A. Cushing Revocable Trust dated October 17, 2023 | 1105 Beech Avenue | Pine Bluffs | WY | 82082 | ORRI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | Moondance Minerals LP | P.O. Box 8445 | Denver | CO | 80201 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | MTG |
| | Clear Creek Fund I-B, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | MTG |
| | U.S. Bank Trust Company, N.A. | 425 Walnut Street, 6th Floor | Cincinnati | OH | 45202 | MTG |
| | U.S. Bank Trust Company, N.A. | 425 Walnut Street, 6th Floor | Cincinnati | OH | 45202 | MTG |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | WI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | MI |
| | Clear Creek Fund I-A, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Double Eagle Energy Rockies, LLC | 1401 Ballinger Street, Suite 203 | Fort Worth | TX | 76102 | WI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI / WI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Noble Energy, Inc. | 1625 Broadway, Suite 2200 | Denver | CO | 80202 | MTG |
| | Cirque Brennsee, LLC | 475 17th Street, Suite 1600 | Denver | CO | 80202 | WI |
| | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 | WI |
| | Jeanie M. Grogan | 613 SW Drive | Cheyenne | WY | 82007 | MI |
| | Katherine Tippy Castello aka K. Tippy Costello | 1209 W. 22nd Street | Cheyenne | WY | 82001 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | James E. and Kina M. Costello Family Trust dated December 23, 1999 | 613 SW Drive | Cheyenne | WY | 82007 | MI |
| | Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| T12N - R63W<br>Sec. 9: All | Kyle W. Breeden and Katherine Tippy Costello, hw as t/b/e | 149 County Road 143 | Carpenter | WY | 82054 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | LPR Investments South LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | MI |
| | Ardith A. Cushing Revocable Trust dated October 17, 2023 | 1105 Beech Avenue | Pine Bluffs | WY | 82082 | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | WI |
| | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 | WI |
| | Noble Energy, Inc. | 1625 Broadway, Suite 2200 | Denver | CO | 80202 | WI |
| | Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | ROW |
| | Riverstone Credit Management Cortland Capital Market Services, LLC | 225 West Washington Street<br>21st Floor | Chicago | IL | 60606 | MTG |
| T12N - R63W<br>Sec. 10: All | Grace Valley, LLC | P.O. Box 391 | Carpenter | WY | 82054 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | Rearden Minerals, LLC | 5914 W. Courtyard Drive | Austin | TX | 78730 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Bill Barkley | 10115 Branding Iron Drive | Cheyenne | WY | 82009 | MI |
| | Gerald R. and Carl E. Zimmerman, co-trustees of the Laura E. Zimmerman Family Trust, created 5/29/2006 | Unknown Address | | | | MI |
| | John Dean | P.O. Box 1028 | Gilmer | TX | 75644 | MI |
| | Hydrocarbon Holdings, LTD | P.O. Box 1135 | Bridgeview | IL | 604555 | MI |
| | Craig L. Emmanuel | P.O. Box 86 | Laramie | WY | 82073 | MI |
| | Karhu Resources LLC | P.O. Box 272229 | Fort Collins | CO | 80527 | MI |
| | Keith Michael Foster and Lisa Marie Foster, JTwROS | 13824 West Amherst Way | Lakewood | CO | 80228 | MI |
| | Brian M. Foster | 13824 West Amherst Way | Lakewood | CO | 80228 | MI |
| | Catherine M. Enzo | 12230 Cherry Street | Thornton | CO | 80241 | MI |
| | Rory G. Owens | 220 Chapel Hill Drive | Prosper | TX | 75078 | MI |
| | Blaise E. McEwan | 5825 Bay Point Drive | Lake Oswego | OR | 97032 | MI |
| | Courtney R. Jones | 10810 Yeomans Park Drive | Colorado Springs | CO | 80908 | MI |
| | O S Property Development | 881 Ocean Drive, Casa De; Mar, Apartment 6G | Key Biscayne | FL | 33149 | MI |
| | Patricia Pico | 14438 Kingston Cove Lane | Houston | TX | 77077 | MI |
| | J15, LLC | P.O. Box 31749 | Palm Beach Gardens | FL | 33420 | MI |
| | Robert P. Dykes, as Trustee of The Robert P. Dykes Revocable Trust, dated 10/14/2011 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | J. Christopher Dykes, as Trustee of The J. Christopher Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Michael L. Dykes, as Trustee of The Michael L. Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Sharon McDonald | 107 Roger's Lane, CR 302 | Durango | CO | 81303 | MI |
| | Terry Lee Faber | 2901 Hermosa Court | Grand Junction | CO | 81504 | MI |
| | Natalie Shea Faber-Padmos | 263 River Vlley Road, #06-17 | Singapore | | 238309 | MI |
| | Neal Brent Faber | 3504 A Cannon Street | Twentynine Palms | CA | 29910 | MI |
| | McCulliss Oil & Gas, Inc. | P.O. Box 221515 | Denver | CO | 80222 | MI |
| | McCulliss Resources Co., Inc. | P.O. Box 3248 | Littleton | CO | 80161 | MI |
| | George G. Vaught, Jr. | P.O. Box 13557 | Denver | CO | 80201 | MI |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Farmers Bank | P.O. Box 220 | Ault | CO | 80610 | MTG |
| | Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 | NPRI |
| | Mark Strader | 14932 Turn Bridge Drive | Frisco | TX | 75035 | NPRI |
| | Joshus D. Vance and Brandy E. Vance, JT | 108 Woodland Drive | Krugerville | TX | 76227 | NPRI |
| | Victoria A. Ladd | 608 Wentworth Drive | McKinney | TX | 75070 | NPRI |
| | James S. Witherell Trust Dated 6/17/1997, James S. Witherell, Trustee | 2610 Deep Cut Road | Woodstock | IL | 60098 | NPRI |
| | William E. Hill and Jan C. Hill, husband and wife | 91 Wood Road | Centereach | NY | 11720 | NPRI |
| | ELSR LP, A Texas Limited Partnership, Bengal Jones Group LLC, General Partner | 8080 North Central Expressway, Suite 1420 | Dallas | TX | 75206 | NPRI |
| | Mariemont Properties, Inc | 3429 Southwestern Boulevard | Dallas | TX | 75225 | NPRI |
| | Karl Schreiber | 5100 Miller Road | Brecksville | OH | 44141 | NPRI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Bambi Fernandez 2004 Trust | 1637 Edmonton Avenue | Sunnyvale | CA | 94087 | NPRI |
| | Thomas E. Shows and Edna M. Shows, JT | 150 Tom Shows Road | Seminary | MS | 39479 | NPRI |
| | Charles Fuller 2006 Trust, Charles F. Fuller, Trustee | 722 Jacaranda Circle | Hillsborough | CA | 94010 | NPRI |
| | Zachary Gleit, Trustee of the Roberta Gleit Revocable Trust dated February 24, 2018 | 4301 North Ocean Boulevard | Boca Raton | FL | 33431 | NPRI |
| | Thomas J. Buckley | 2310 Royal Oaks Drive | Mansfield | TX | 76063 | NPRI |
| | Mitsuo Fuse | 14901 Quorum Drive, # 800 | Dallas | TX | 75254 | NPRI |
| | Tommarr, LLC | 108 Nickerson Lane | Romeo | ME | 04963 | NPRI |
| | Thomas A. Alico | 410 Waterside Lane | Nokomis | FL | 34275 | NPRI |
| | Ken Ward and Janet Ward, JT | 732 Bluff Ridge Drive | Cedar Hill | TX | 75104 | NPRI |
| | Gerald E. Werner | 10254 South 700 West | Union Mills | IN | 46382 | NPRI |
| | Barry A. Craft | 6416 Aston Park Drive | Oak Ridge | NC | 27310 | NPRI |
| | Edward N. Strader and Carol N. Strader, JTwROS | 3718 Dover Road | Cheyenne | WY | 82001 | NPRI |
| | Ralf R. Filler and Loretta D. Filler, JT | 4715 Langford Lane | Wichita Falls | TX | 76310 | NPRI |
| | John R. Sellers | 4019 West 176th Street | Torrance | CA | 90504 | NPRI |
| | Dimple Dene Hummer | 5901 Forest Ledge | San Antonio | TX | 78240 | NPRI |
| | David A. Dent | 6712 Arrowhead Pass | Edina | MN | 55439 | NPRI |
| | Brian Summer | 46 Conway Street, Suite B | Shellburne Falls | MA | 01370 | NPRI |
| | Wake Family Living Trust Dated 1/5/1994, Harold E. Wake, Trustee | 1013 Oakwook Circle | Carmel | CA | 93923 | NPRI |
| | The Jacobson Family Trust UA Dated 1/5/1994, Elaine Virginia Jacobson, Trustee | 1864 Lime Tree Lane | Mountain View | CA | 94040 | NPRI |
| | Albert Goodis and Barbara Buck, Individually | 111 Water Rock Circle | Wayneville | NC | 28786 | NPRI |
| | Jack E. Earnest | 5945 Shady Circle Drive | Houston | TX | 77057 | NPRI |
| | Warren Lawrence and Nanch Kay Lawrence, JT | 2535 South Newton Street | Denver | CO | 80219 | NPRI |
| | David W. Galehouse and Deborah K. Hartman, JT | 3216 Deweese Parkway | Dayton | OH | 45414 | NPRI |
| | John Spicer | 5956 Bannock Hwy | Pocatello | ID | 83204 | NPRI |
| | Ted N. Steffen Trust (or his successor) of a Trust created on 2/3/2003 | 2404 Barret Hill Road | Louisville | KY | 40205 | NPRI |
| | Grant W. Avery Declaration of Trust dated 6/20/2008 | 15543 Southeast Frontage Road | Plainfield | IL | 60544 | NPRI |
| | Michael E. Cherry | 49273 295th | Genoa | NE | 68640 | NPRI |
| | Andrew L. Peabody | P.O. Box 2120 | Natchez | MS | 39121 | NPRI |
| | Rodella Vergamini and John Vergamini, TIC | 146 Vine Street | Council Bluffs | IA | 51503 | NPRI |
| | George A. Longo | 505 North West CR 0011 | Corsicana | TX | 75110 | NPRI |
| | Dale Harlan | 7005 Wagon Train Road | Hickman | NE | 68372 | NPRI |
| | Robert E. Dettle and Rosalie T. Dettle Living Trust Dated 2/29/1980, Robert E. Dettle, Trustee | 1101 Water Street | Santa Cruz | CA | 95062 | NPRI |
| | Richard B. Juenemann Revocable Trust Dated 7/18/2007, Richard B. Junemann, Trustee | 32768 220th Street | Sanborn | MN | 56083 | NPRI |
| | Vincent Kunderman | 17319 Hilltop Ridge Drive | Eureka | MO | 63025 | NPRI |
| | Jim Mamot | 233 Friend Road | St. Liberty | NE | 68872 | NPRI |
| | Jim Clayton | 1258 Whispering Oaks | Desoto | TX | 75115 | NPRI |
| | Derk Smith | 3321 Heritage Lake Drive | Lockport | IL | 60441 | NPRI |
| | John C. Peterson and Bernadette J. Peterson, JT | 12472 89th Place | Maple Grove | MN | 55369 | NPRI |
| | Preston Real Estate, LLC | 11904 Arbor Street, Suite 200 | Omaha | NE | 68114 | NPRI |
| | Maryl Betzwiser | 6369 Whitetail Ridge Court | Yorkville | IL | 60560 | NPRI |
| | Brian H. Davis | 628 Aqua Circle | Lino Lakes | MN | 55014 | NPRI |
| | Judith L. Avery | 23524 West Copper Drive | Plainfield | IL | 60544 | NPRI |
| | Karl A. Willey Rev. Trust, Karl A. Willey, Trustee | 412 North Young | Caldwell | KS | 67022 | NPRI |
| | Karl A. Glastad | 8 Sunset Trail | Heath | TX | 75032 | NPRI |
| | Matthew Witherell and Kristin L. Witherell, JT | 4 Oxford Drive | Rogers | AR | 72758 | NPRI |
| | Alton Dwyer | 6921 South West 178th Avenue | Southwest Ranches | FL | 33331 | NPRI |
| | Kenneth W. Morris | 2121 Haas Road | Apopka | FL | 32712 | NPRI |
| | C Three J, LLC | 13705 Highway 11 | Allendale | IL | 62410 | NPRI |
| | Bernard Caputo | 34 Woodcrest Road | Boxford | MA | 01921 | NPRI |
| | RAL Farms LLC, an Indiana Limited Liability Company | 13525 Bunker Hill Lane | St. Francisville | IL | 62460 | NPRI |
| | Harold R. Barr | 4299 South 75 West | Laporte | IN | 46350 | NPRI |
| | Robert l Canvarl Jr. | 6237 Ella Lee Lane | Houston | TX | 77057 | NPRI |
| | Ruby Resources, LLC | 1530 P B Ln # 3592 | Wichita Falls | TX | 76302-2612 | NPRI |
| | Arthur G. Rice | 5228 US Hwy 421 N | Wilmington | NC | 28401 | NPRI |
| | Provident Trust Group, LLC as custodian FBO Dennis J. Kulonda Traditional IRA 180901668 | 8880 Sunset Road, Suite 250 | Las Vegas | NV | 89148 | NPRI |
| | RDMB Holdings, Inc | 3106 Druid Hill Drive | Des Moines | IA | 50315 | NPRI |
| | Thomas E. Werlin | 62 Legend Lane | Houston | TX | 77024 | NPRI |
| | Gerald W. Simonson | 5813 Jeff Place | Edina | MN | 55436 | NPRI |
| | Ivan K. Gilling | 14250 County Road AA | La Jara | CO | 81140 | NPRI |
| | Equity Trust Company Custodian FBO Gary F. Hansen IRA | 225 Burns Road | Elyria | OH | 44035 | NPRI |
| | Gary Larson and Jeanine D. Larson, JT | 715 N. 25th St | Mesa | AZ | 85213 | NPRI |
| | IRA Resources, Inc., FBO: Harry W. Buehrle, II IRA 32486 | 6825 La Jolla Boulevard | La Jolla | CA | 92037 | NPRI |
| | Equity Trust Company Custodian FBO Arthur J. Powell Jr. IRA | P.O. Box 1529 | Elyria | OH | 44035 | NPRI |
| | Leopoldo Rodriguez | 4206 Ridgelane Drive | Colorado Springs | CO | 80918 | NPRI |
| | Equity Trust Company Custodian FBO Matthew V. Lee JR., Roth IRA #43612F77 | 225 Burns Road | Elyria | OH | 44035 | NPRI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Ralph A. Bard, III | 59-425 Makana Road | Haleiwa | HI | 96712 | NPRI |
| | Advanta IRA Trust, LLC FBO: Gale E. Christenson IRA xxx6601 | 1520 Royal Palm Square Boulevard #320 | Fort Myers | FL | 33919 | NPRI |
| | Advanta IRA Trust, LLC FBO: Mark K. Christenson IRA xxx6401 | 1520 Royal Palm Square Boulevard #320 | Fort Myers | FL | 33919 | NPRI |
| | Equity Trust Company Custodian FBO Kent Nygren IRA | 225 Burns Road | Elyria | OH | 44035 | NPRI |
| T12N - R63W | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | SI / MI |
| Sec. 11: NE | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 | MI |
| | Kaiser-Francis Oil Company | P.O. Box 21468 | Tulsa | OK | 74121 | WI |
| | American Shale Energy LLC | 2929 Buffalo Speedway Suite 2106 | Houston | TX | 77098 | WI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ORRI |
| | Mark R. Stagg, life estate with remaindermen being his children Kristine Stagg, Josephine Stagg, Jacqueline Stagg, Jeannette Stagg and Julianne Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | WI |
| | Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 | MTG |
| T12N - R63W | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | SI |
| Sec. 11: NW | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI / WI |
| | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI / ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 | MTG |
| T12N - R63W | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | SI / MI |
| Sec. 11: SW | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | MI |
| | Longs Peak Resources, LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | WI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch 90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R63W | JFK Ag, LLC | 37174 County Road 124 | Grover | CO | 80729 | **SI** |
| Sec. 11: SE | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch 90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | WI |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI / ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R63W | Emmanuel Farm LLP | 220 Road 148 | Carpenter | WY | 82054 | SI |
| Sec. 12: NE | The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | HRM Resources II, LLC | 410 17th Street, Suite 1600 | Denver | CO | 80202 | ORRI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI / ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R63W<br>Sec. 12: NW | The te Velde Family LLLP | 7619 Road 19 | Fort Lupton | CO | 80621 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 | MI |
| | Kaiser-Francis Oil Company | P.O. Box 21468 | Tulsa | OK | 74121 | WI |
| | American Shale Energy LLC | 2929 Buffalo Speedway<br>Suite 2106 | Houston | TX | 77098 | WI |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ORRI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | Mark R. Stagg, life estate with remaindermen being his children Kristine Stagg, Josephine Stagg, Jacqueline Stagg, Jeannette Stagg and Julianne Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 | MI |
| | Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 | MI |
| | Charles W. and Patty N. Brown, LLC | P.O. Box 587 | Marlow | OK | 73055 | MI |
| | Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | MAP2009-OK c/o MAP Royalty, Inc. | 101 North Robinson Avenue, Suite 1000 | Oklahoma City | OK | 73102 | MI |
| | Bold Resources, LLC | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Bluebird Energy Partners, LLC | 9055 E. Mineral Circle, Suite 110 | Centennial | CO | 80112 | MI |
| | Oxford Exploration, LLC | 450 East 17th Avenue<br>Suite 320 | Denver | CO | 80203 | MI |
| | BFG Minerals, LLC | 225 S. Broadway, Suite 9847 | Denver | CO | 80209 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Farmers State Bank | P.O. Box 252 | Chadron | NE | 63337 | MTG |
| | American Agcredit, FLCA | P.O. Box 1120 | Santa Rosa | CA | 95402 | MTG |
| T12N - R63W<br>Sec. 12: SW, N2SE, SWSE | Emmanuel Farm LLP | 220 Road 148 | Carpenter | WY | 82054 | SI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1600 | Denver | CO | 80202 | ORRI |
| | LPR Investments South LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | MI |
| | Anadarko E&P Company, L.P. | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | ORRI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Texas American Resources Co. | 410 17th Street, Suite 1610 | Denver | CO | 80202 | ROW |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI / ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| | Wells Fargo Bank , N.A. | 1700 Lincoln Street<br>Third Floor MAC C7300-003 | Denver | CO | 80203 | MTG |
| T12N - R63W<br>Sec. 12: SESE | Anita Ruth Johnson<br>c/o Barbara Duggan | P.O. Box 35 | Hereford | CO | 80732 | SI / MI |
| | Mark Jenkins | 20030 WCR 33 | LaSalle | CO | 50645 | MI |
| | Karen R. Jenkins | 20030 WCR 33 | LaSalle | CO | 50645 | MI |
| | Kathaleen Ann Eastman-Lorenz | P.O. Box 1863 | Lihue | HI | 96766 | MI |
| | Morgan Jane Eastman-Lorenz | P.O. Box 1863 | Lihue | HI | 96766 | MI |
| | Camden Carol Lorenz | P.O. Box 1863 | Lihue | HI | 96766 | MI |
| | Wolfhawk Energy Holdings, LLC | 999 18th Street, Suite 1605S | Denver | CO | 80202 | MI |
| | Francis W. Blake | 5700 East CR 48 | Fort Collins | CO | 80524 | MI |
| | Francis W. Blake, Trustee of the Ettie P. Blake Living Trust, dated 08-15-1988 | 5700 East CR 48 | Fort Collins | CO | 80524 | MI |
| | McClintock & Nikoloric, LLC, BOKF, NA dba Colorado State Bank and Trust, Agent | P.O. Box 3499 | Tulsa | OK | 74101 | MI |
| | Bank of Oklahoma, N.A., as Agent for U.S. Bank, N.A., Trustee of the T.E. McClintock T/U/W fbo Mary M. Swift | P.O. Box 3499 | Tulsa | OK | 74101 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | David E. Honeycutt | 401 Congress Ave., Suite 1600 | Austin | TX | 78701 | ORRI |
| | Sarah Ann Honeycutt | 1405 Meriden Lane | Austin | TX | 78703 | ORRI |
| | Tim Taylor | 4832 Amesley Cove | Austin | TX | 78727 | ORRI |
| | Cecile Bott | 2449 Westlake Drive | Austin | TX | 78746 | ORRI |
| | Troy Gieselman | 2000 Pursley Road | Dripping Springs | TX | 78620 | ORRI |
| | Thomas Rogers | 13935 Shannon Drive | Broomfield | CO | 80023 | ORRI |
| | Soraya E. Copeland | 18121 Angel Valley Drive | Leander | TX | 78641 | ORRI |
| | Drew Pinzur | 804 East 45th 1/2 Street | Austin | TX | 78751 | ORRI |
| | Jared Rush | 4481 Quitman Street | Denver | CO | 80212 | ORRI |
| | Jason Brand | 5453 Maggie Lane | Evergreen | CO | 80439 | ORRI |
| | Kate Capotosto | 602 Territory Cove | Cedar Park | TX | 78613 | ORRI |
| | Chris Woll | 5818 Republic of Texas Blvd. | Austin | TX | 78735 | ORRI |
| | HRM Resources II, LLC | 410 17th Street, Suite 1600 | Denver | CO | 80202 | ORRI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | ORRI |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Capital One, National Association | 1000 Louisiana St, Suite 2950 | Houston | TX | 77002 | MTG |
| T12N - R63W<br>Sec. 13: All | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Todd Alan Martin and Sydnee Marie Martin as Co-Trustees of the Todd Alan Martin and Sydnee Marie Martin Marital Trust u/t/a dated 11-21-2019 | 169 County Road 148 | Carpenter | WY | 82054 | SI |
| | Arnold and Jeanne Bautista | 94 Road 148 | Carpenter | WY | 82054 | SI |
| | Anita Ruth Johnson<br>c/o Barbara Duggan | P.O. Box 35 | Hereford | CO | 80732 | SI / MI |
| | United States of America / | 5353 Yellowstone Road | Cheyenne | WY | 82009 | MI |
| | Mountain States Telephone and Telegraph Company | Unknown Address | | | | ROW |
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | ROW |
| | State of Wyoming<br>Office of State Lands & Investments | Herschler Building<br>122 W. 25th Street - W103 | Cheyenne | WY | 82002 | MTG |
| | Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 | MTG |
| | Meridian Trust Federal Credit Union | P.O. Box 548 | Cheyenne | WY | 82003 | MTG |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Ware Family, LLC c/o Yvonne L. Ware | P.O. Box 423 | Carpenter | WY | 82054 | MI |
| | L P R Investment South, LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | MI |
| | June Cushing | Unknown Address | | | | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis and Ardith A. Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Russell Mosier c/o Mark and Karen Jenkins | 11776 County Road 42 | Platteville | CO | 80651 | MI |
| | Wolfhawk Energy Holdings, LLC | 999 18th Street, Suite 16508 | Denver | CO | 80202 | MI |
| | Kathleen Eastman-Lorenz, Successor Trustee of the Michael Philip Lorenz Revocable Living Trust | P.O. Box 1863 | Lihue | HI | 96766 | MI |
| | U.S. National Bank NA, Trustee of the T. E. McClintock Mineral Trust c/o US Bank | P.O. Box 17532 | Denver | CO | 80217 | MI |
| | Francis W. Blake, Trustee of the Ettie P. Blake Living Trust, dated 08-15-1988 | 5700 East CR 48 | Fort Collins | CO | 80524 | MI |
| | Francis W. and E. Joanne Blake | P.O. Box 79 | Hereford | CO | 80732 | MI |
| | The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083 | MI |
| | Mark and Karen R. Jenkins | 20030 WCR 33 | LaSalle | CO | 80645 | MI |
| | Phillip and Rudy Breeden | Unknown Address | | | | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| T12N - R63W<br>Sec. 14: All | Chase Bank of Texas, NA, fka Texas Commerce Bank, NA | 600 Travis Street, 20th Floor | Houston | TX | 77002 | MTG |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Roaring Fork Midstream LLC | 2323 South Shepherd Drive<br>Suite 1150 | Houston | TX | 77019 | ROW |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ROW |
| | Richard Breeden | Unknown Address | | | | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Gary Breeden | Unknown Address | | | | MI |
| | Susie Breeden | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | MI |
| | Thomas V. Breeden | 565 S. Parfet | Lakewood | CO | 80226 | MI |
| | June Cushing | Unknown Address | | | | MI |
| | John Francis and Ardith A. Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | Harvey Miller | Unknown Address | | | | MI |
| | John H. Hueske | Unknown Address | | | | MI |
| | Francis Cushing | Unknown Address | | | | MI |
| | The Federal Land Bank of Omaha | 206 S. 19th St. | Omaha | NE | 68102 | MI |
| | Harold F. Baumgartner | Unknown Address | | | | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | SI / MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | SI / MI |
| | Sandra A. Meyers | Unknown Address | | | | MI |
| | Abby Jo Ragan | Unknown Address | | | | MI |
| T12N - R63W | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | SI / MI |
| Sec. 15: NE | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Burnett Land & Livestock, Ltd. | 5453 County Road 202 | Carpenter | WY | 82054 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Susan K. Breeden | 2702 19th Street Drive, #17 | Greeley | CO | 80634 | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | William J. Breeden | 3630 Foxcroft Road | Cheyenne | WY | 82001 | MI |
| | Thomas V. Breeden | 565 S. Parfet | Lakewood | CO | 80226 | MI |
| | Karen Anne Breeder | 631 Ash Street | Windsor | CO | 80550 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 | MTG |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R63W | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | SI / MI |
| Sec. 15: NW | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Burnett Land & Livestock, Ltd. | 5453 County Road 202 | Carpenter | WY | 82054 | MI |
| | Farm Credit of Southern Colorado, FLCA, a wholly owned subsidiary of Farm Credit of Southern Colorado, ACA | P.O. Box 670 | Burlington | CO | 80807 | MTG |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R63W | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | SI / MI |
| Sec. 15: SW | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R63W | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | SI / MI |
| Sec. 15: SE | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Blue River Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Midcamp Minerals, LLC | 5950 Cedar Springs Road, Suite 100 | Dallas | TX | 75235 | MI |
| | Susan K. Breeden | 2702 19th Street Drive, #17 | Greeley | CO | 80634 | MI |
| | Cheryl Ann Jeffers | 296 County Road 148 | Carpenter | WY | 82054 | MI |
| | John Francis Cushing | P.O. Box 67 | Pine Bluffs | WY | 82082 | MI |
| | LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | MI |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - 63W | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 | WI |
| Sec. 16: All | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | WI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | WI |
| | Halliburton Energy Services, Inc. | 3000 N. Sam Houston Parkway East | Houston | TX | 77032 | WI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | ORRI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | ORRI |
| | Phillip V. Breeden Revocable Trust Dated December 13, 2013 | 90 County Road 143 | Carpenter | WY | 82054 | SI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Phil Kiner and Marsha Kiner, husband and wife | 8225 Arrow Wood Lane | Cheyenne | WY | 82009 | MI |
| | Nancy L. Flynn, Trustee of the Nancy L. Flynn Revocable Trust under agreement dated April 2, 2009, as amended and restated | P.O. Box 289 | Cheyenne | WY | 82009 | MI |
| | Tippy C. Costello | 1209 W. 22nd Street | Cheyenne | WY | 82001 | MI |
| | Jeanie M. Grogan | 613 Southwest Drive | Cheyenne | WY | 82007 | MI |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | Basin Electric Power Cooperative | 1717 E. Interstate Avenue | Bismarck | ND | 58503 | ROW |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ROW |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R63W<br>Sec. 17: All | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | Tulsa | OK | 74119 | WI |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Prism Energy, LLC | 4585 S. Taft Way | Morrison | CO | 80465 | WI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | WI |
| | Maevlo Production, LP | 6140 S. Gun Club Road K6, Box 287 | Aurora | CO | 80016 | ORRI |
| | Silverstone Minerals, LLC | 110 E. Harvard Avenue | Denver | CO | 80210 | ORRI |
| | Fifth Pocket Production, LLC | 555 17th Street, Suite 3700 | Denver | CO | 80202 | ORRI |
| | Kestrel Properties Corp. | P.O. Box 39 | Morrison | CO | 80465 | ORRI |
| | Prism Energy, LLC | 4585 S. Taft Way | Morrison | CO | 80465 | ORRI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ORRI |
| | Phillip V. Breeden Revocable Trust Dated December 13, 2013 | 90 County Road 143 | Carpenter | WY | 82054 | SI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Phil Kiner and Marsha Kiner, husband and wife | 8225 Arrow Wood Lane | Cheyenne | WY | 82009 | MI |
| | Nancy L. Flynn, Trustee of the Nancy L. Flynn Revocable Trust under agreement dated April 2, 2009, as amended and restated | P.O. Box 289 | Cheyenne | WY | 82009 | MI |
| | Tippy C. Costello | 1209 W. 22nd Street | Cheyenne | WY | 82001 | MI |
| | Jeanie M. Grogan | 613 Southwest Drive | Cheyenne | WY | 82007 | MI |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Mark T. Cox, III and Elizabeth J. Cox, husband and wife | P.O. Box 47 | Cheyenne | WY | 82009 | ROW |
| | Basin Electric Power Cooperative | 1717 E. Interstate Avenue | Bismarck | ND | 58503 | ROW |
| | EOG Resources, Inc. | 600 17th Street, Suite 1000N | Denver | CO | 80202 | ROW |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T12N - R63W<br>Sec. 21: N2 | Phillip V. Breeden Revocable Trust Dated December 13, 2013 | 90 County Road 143 | Carpenter | WY | 82054 | SI |
| | Philip V. Breeden | Box 3 Ranch | Carpenter | WY | 82054 | MI |
| | Tri-State Generation & Transmission Association, Inc. | 12076 Grant Street | Thornton | CO | 80241 | ROW |
| | Wyoming Western Oil | P.O. Box 458 | Pine Bluffs | WY | 82082 | ROW |
| | Zarephath LLC | 4520 14th Street Drive | Greeley | CO | 80524 | ROW |
| | Fifth Creek Energy Operating | 5251 DTC Parkway, Suite 420 | Greenwood Village | CO | 80111 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | WI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| T12N - R63W<br>Sec. 22: All | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | WI / MI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI / ROW |
| | Occidental Petroleum Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Overland Energy Partners I, LLC | 518 17th Street, #1005 | Denver | CO | 80202 | MI |
| | Fifth Creek Energy Operating Company, LLC | 5251 DTC Parkway, Suite 420 | Greenwood Village | CO | 80111 | WI |
| | OG Resources, Inc. | Unknown Address | | | | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Incline Niobrar Parnters, L.P. | 5019 N. Central Expressway, Suite B | Dallas | TX | 75205 | WI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | Michael D. Konig and Tena M. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | SI / MI |
| | Gary D. Rohrbouck | 2170 Pacific Road | Gering | NE | 69341 | SI / MI |
| | Scott D. Rohrbouck | 571 Hourglass Court | Loveland | CO | 80537 | SI / MI |
| | Tammy J. Tenley | 336 Silas Court | Spring Hill | FL | 34609 | SI / MI |
| | Wyoming Western Oil | P.O. Box 458 | Pine Bluffs | WY | 82082 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Superior Oilfield Services Co., LTD | P.O. Box 336356 | Greeley | CO | 80633 | ROW |
| | Exterra Resources, LLC | 256 Seaboard Lane, H101 | Franklin | TN | 37067 | WI |
| | International Lutheran Laymen's League | 660 Mason Ridge Center Dr. | St. Louis | MO | 63141 | MI |
| | Apollo Operating, LLC | 1538 Wazee Street, Suite 200 | Denver | CO | 80202 | WI |
| | DJ Resources Holdings, LLC | One Riverway, Suite 1870 | Houston | TX | 77056 | ORRI |
| | Old West Tours | 601 16th St., Suite C-153 | Golden | CO | 80401 | ORRI |
| | NG Resources, LLC | 9896 Clairton Way | Highlands Ranch | CO | 80126 | ORRI |
| | Stafford Investments, LTD. | P.O. Box 11115 | Midland | TX | 79702-1115 | MI |
| | JLW Investment, LLC | 351 Glencoe Street | Denver | CO | 80220 | ORRI |
| | JH Petroleum, LLC | P.O. Box 621128 | Littleton | CO | 80162-1128 | ORRI |
| | SSALJD Investment Group LLC | P.O. Box 280969 | Lakewood | CO | 80228-0969 | ORRI |
| | Louis A. Oswald, III, Trustee fo the Oswald Family Trust, dated April 27, 1998 | P.O. Box 280969 | Lakewood | CO | 80228-0969 | ORRI |
| | Kelly V. Oswald | 5638 Sanford Road | Houston | TX | 77096 | ORRI |
| | Brent A. Oswald | 1304 Yorkshire Drive | Austin | TX | 78723 | ORRI |
| | Elsie Bettge | 1217 Spruce Dr. | Knoxville | TN | 37920 | ORRI |
| | Albert E. Kranz and Michelle L. Kranz | 406 E. 3rd | Pine Bluffs | WY | 82082 | ORRI |
| | Esther M. Lewis and Duwayne Lewis | 10905 Empire Dr. | Cheyenne | WY | 82009 | MI |
| | Paul C. Mclaury | 300 E. Prosser Rd., Space 17 | Cheyenne | WY | 82007 | ORRI |
| | Shirley Price | 3064 Grier Blvd. | Cheyenne | WY | 82001 | MI |
| | Edward A. Kranz and Julie C. Kranz | 484 County Road 151 | Carpenter | WY | 82054 | ORRI |
| | Kaiser-Francis Oil Company | P.O. Box 21468 | Tulsa | OK | 74121-1468 | WI |
| | Don A. Kranz, Trustee of the Don A. Kranz Revocable Trust, dated April 27, 2016 | 493 County Road 154 | Carpenter | WY | 82054 | MI |
| | Lynne M. Kranz, Trustee of the Lynne M. Kranz Revocable Trust, dated April 27, 2016 | 493 County Road 154 | Carpenter | WY | 82054 | MI |
| | The Lutheran Home | 530 South 26th Street | Omaha | NE | 68105 | MI |
| | Ivan Lee Kranz | 861 County Road 150 | Carpenter | WY | 82064 | MI |
| | Shirley Helen Rose | 3064 Grier Blvd. | Cheyenne | WY | 82001 | WI |
| | Barbara A. Ittig | 44265 Compeigne Drive | Hemet | CA | 92544 | MI |
| | Leona Buhlmann | 42473 Drive 743 | Elwood | NE | 68937 | MI |
| | Jane E. Pihl | 15648 SW Highway 126 | Powell Butte | OR | 97753 | MI |
| | The Oswald Family Irrevocable Trust | 7200 S. Alton Way, Suite B-250 | Centennial | CO | 80112 | ORRI |
| | Calf Creek Royalty, Ltd. | P.O.Box 3240 | Midland | TX | 79702 | MI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121-1468 | WI |
| | Stephen Deaver aka The Reverend Stephen Deaver | 615 W. 42nd Street | Scottsbluff | NO | 69361 | MI |
| | Sisters of St. Francis | 5314 N. Columbine Road | Denver | CO | 80221 | ORRI |
| | Sandra Ann Anthony | 6401 Ohio Drive, Apt. 1104 | Plano | TX | 75024 | ORRI |
| | Father Richard Rohr aka The Reverend Richard Rohr, O.F.M. | P.O. Box 12464 | Albuquerque | NM | 87195 | MI |
| | Food for the Poor, Inc. | 6401 Lyons Road | Coconut Creek | FL | 33073 | MI |
| | Jeff Tracy | 1416 8th Avenue | Scottsbluff | NE | 69361 | MI |
| | Top Notch Land Services, Inc. | P.O. Box 328 | Kimball | NE | 69145 | WI |
| | CNOOC Energy U.S.A. LLC | 945 Bunker Hill Road, Suite 1000 | Houston | TX | 77024 | MI |
| | Verdad Resources, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 | WI |
| | Catholic Relief Services | 228 W. Lexington St. | Baltimore | MD | 21201-3443 | MI |
| | Center of Action and Contemplation | P.O. Box 12464 | Albuquerque | NM | 87195 | MI |
| | JP Morgan Chase Bank, N.A. | 1125 17th St., Floor 2 | Denver | CO | 80202 | MTG |
| | Del Rio Royalty Company, LLC | 3400 S. Broadway, Suite 100 | Englewood | CO | 80113 | MI |
| | Anthony LLC | 21 Dowd Court | Kimball | NE | 69145 | MI |
| | WK Land Company | 911 Kimbark St. | Longmont | CO | 80501 | MI |
| | Suzanne Beverly Hart | c/o Diane Deutsch<br>848 E. Windsor Dr. | Gilbert | AZ | 85296 | MI |
| T12N - R63W<br>Sec. 23: All | The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083-1100 | MI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Occidental Petroleum Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | WI |
| | Scout Partners, LLC | P.O. Box 1348 | Edmond | OK | 73083- | WI |
| | Fifth Creek Energy Operating Company, LLC | 5251 DTC Parkway, Suite 420 | Greenwood Village | CO | 80111 | WI |
| | Clear Creek Fund I-B, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Pawnee Butte Royalties, LLC | P.O. Box 4631 | Englewood | CO | 80155 | MI |
| | LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | MI |
| | Longs Peak Resources, LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | WI |
| | Overland Energy Partners Fund II, LLC | 700 17th Street, Suite 900 | Denver | CO | 80202 | MI |
| | Wolf Resources, LLC | 621 17th St., Ste 1601 | Denver | CO | 80293 | MI |
| | Oxford Exploration, LLC | 4200 E. 8th Ave., Suite 102 | Denver | CO | 80220 | WI |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | MI / WI |
| | Wyoming Western Oil | P.O. Box 458 | Pine Bluffs | WY | 82082 | ROW |
| | Susan K. Breeden | 2702 19th Street Drive, #17 | Greeley | CO | 80634 | MI |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 | NPRI |
| | McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Halliburton Energy Services, Inc. | 2107 City West Blvd., Building 2 | Houston | TX | 77042 | NPRI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Proved Reserves, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 | MI |
| | Double Eagle Energy Rockies, LLC | 1401 Ballinger Street, Suite 203 | Fort Worth | TX | 76102 | WI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | WI |
| | Mountaintop Minerals | 370 17th St., Ste 5200 | Denver | CO | 80202 | WI |
| | R. K. Pinson & Associates, LLC | 621 17th St., Suite 1555 | Denver | CO | 80293 | WI |
| | Extraction Oil & Gas LLC | 370 17th St., Ste 5200 | Denver | CO | 80202 | WI |
| | Lincoln Energy Partners IV, LLC | 3400 S. Broadway, Suite 100 | Englewood | CO | 80113 | MI |
| | Mary Lou King and Austin Dale King | P.O. Box 476 | Kellogg | ID | 83837 | MI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Incline Niobrar Parnters, L.P. | 5019 N. Central Expressway, Suite B | Dallas | TX | 75205 | WI |
| | SAG Ag, LLC | 58710 County Road 81 | Grover | CO | 80729 | SI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | William J. Breeden, Thomas J. Breeden and Karen Breeden | 3630 Foxcroft Road | Cheyenne | WY | 82001 | MI |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | Brighton Mineral Holdings, LLC | P.O. Box 669 | Englewood | CO | 80151-0669 | MI |
| | Superior Oilfield Services Co., LTD | P.O. Box 336356 | Greeley | CO | 80633 | ROW |
| T12N - R63W<br>Sec. 24: All | The Prospect Company | P.O. Box 1100 | Edmond | OK | 73083-1100 | MI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Occidental Petroleum Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Sherryl E. Faris | 2238 Peru Road | Peru | IA | 50222 | MI |
| | Scout Partners, LLC | P.O. Box 1348 | Edmond | OK | 73083- | WI |
| | Johnnie Christensen and Patsy Christensen | 5200 Allan Road | Cheyenne | WY | 82009 | MI |
| | Carolyn Hern and Gerald L Hern | 55 Barstow Bridge Road | Kettle Falls | WA | 99141 | MI |
| | Darlene Hughes | P.O. Box 1115 | Kettle Falls | WA | 99141 | MI |
| | Shirley Melton | 5052 Archer Lane North | Plymouth | MN | 55446 | MI |
| | Dale Mitchell and Judy M. Mitchell | P.O. Box 356 | Lyle | WA | 98635 | MI |
| | Syliva J. Parvin and Robert A. Parvin | P.O. Box 144 | Rock River | WY | 82083 | MI |
| | James Patrick Sullivan and Deanna C. Sullivan | 11413 Glencoe Drive | Cheyenne | WY | 82009 | MI |
| | Albert John Faris and Betty Lou Faris | P.O. Box 53 | Rock River | WY | 82083 | MI |
| | Marjorie Louise Faris Revocable Living Trust dated March 21, 2003<br>Marjorie Louise Faris as Trustee | 1506 Willow Street | San Diego | CA | 92106 | MI |
| | April Sims | 1991 CR 1 #A | McFadden | WY | 82083 | MI |
| | Winnie L. Stephan as Trustee of the Winnie L. Stephan Revocable Trust, dtd December 8, 2011 | P.O. Box 692 | Cheyenne | WY | 82003 | MI |
| | Guy Faris | 179 Indian Ridge Road | Pavillion | WY | 82523 | MI |
| | Patricia R. Walder-Christner | 6907 Willshire Blvd. | Cheyenne | WY | 82009 | MI |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 | NPRI |
| | McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 | WI |
| | Halliburton Energy Services, Inc. | 2107 City West Blvd., Building 2 | Houston | TX | 77042 | NPRI |
| | Breeden Mineral Holdings LLC | Box 3 Ranch<br>90 County Road 143 | Carpenter | WY | 82054 | MI |
| | Proved Reserves, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 | MI |
| | Double Eagle Energy Rockies, LLC | 1401 Ballinger Street, Suite 203 | Fort Worth | TX | 76102 | WI |
| | 8 North, LLC | 370 17th Street, Suite 5300 | Denver | CO | 80202 | WI |
| | R. K. Pinson & Associates, LLC | 621 17th St., Suite 1555 | Denver | CO | 80293 | WI |
| | Extraction Oil & Gas LLC | 370 17th St., Ste 5200 | Denver | CO | 80202 | WI |
| | Michael Sullivan | P.O. Box 1054 | Mesquite | NV | 89024 | MI |
| | Mary Lou King and Austin Dale King | P.O. Box 476 | Kellogg | ID | 83837 | MI |
| | Judy F. Payne and Dale Payne | 41 Dalton Road | Omak | WA | 98841 | MI |
| | Merritt Lacy | 12733 W. Columbine Drive | El Mirage | AZ | 85335 | MI |
| | Incline Niobrar Parnters, L.P. | 5019 N. Central Expressway, Suite B | Dallas | TX | 75205 | WI |
| | Edmond Cook and Tena L. Cook | P.O. Box 1327 | Chadron | NE | 69337 | MI |
| | Wesley J. Faris | 1120 Marcy Street | Ottawa | IL | 61350 | MI |
| | Cindy Jo Hamilton | P.O. Box 214 | Hillsdale | WY | 82060 | MI |
| | Debra Ann Jackson | P.O. Box 75 | Burns | WY | 82053 | MI |
| | Lance Lacy and Tricia Lacy | 15741 W. Ventura Street | Surprise | AZ | 85379 | MI |
| | Grady Faris and Janice Faris | 1854 18th Street | Wheatland | WY | 82201 | MI |
| | Wanda Darlene Hughes | 480 W. 10th Avenue | Kettle Falls | WA | 99141 | MI |
| | Pamela J. Burgener | 19 Nightingale Circle | Camargo | IL | 61919 | MI |
| | Tracey J. Wrobel | 420 Wedgewood Circle | Lake in the Hills | IL | 60156 | MI |
| | Jeffrey C. Mauck | 405 Elm Street | Spring Valley | IL | 61362 | MI |
| | Amy Christine Collins | P.O. Box 1356 | Stenenson | WA | 98648 | MI |
| | Paula Marie Yarger | 4908 F.M. 879 | Palmer | TX | 75152 | MI |
| | Connie Lou Rivas | 751 Avenue C, #45-45 | Cheyenne | WY | 82007 | MI |
| | Jimmie D. Collins | 4408 E. 6th St. | Cheyenne | WY | 82001 | MI |
| | William B. Wilsted and Leanne C. Wilsted | 7378 Augusta Drive | Boulder | CO | 80301 | MI |
| | Apollo Operating, LLC | 1538 Wazee Street, Suite 200 | Denver | CO | 80202 | MI |
| | Fifth Creek Energy Operating Company, LLC | 5251 DTC Parkway, Suite 420 | Greenwood Village | CO | 80111 | WI |
| | Clear Creek Fund I-B, LP | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | JLW Investment, LLC | 351 Glencoe Street | Denver | CO | 80220 | MI |
| | Pawnee Butte Royalties, LLC | P.O. Box 4631 | Englewood | CO | 80155 | MI |
| | LPR Investments South LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | MI |
| | Longs Peak Resources, LLC | 2323 South Shepherd Drive Suite 1150 | Houston | TX | 77019 | WI |
| | Overland Energy Partners Fund II, LLC | 700 17th Street, Suite 900 | Denver | CO | 80202 | MI |
| | Wolf Resources, LLC | 621 17th St., Ste 1601 | Denver | CO | 80293 | MI |
| | Oxford Exploration, LLC | 4200 E. 8th Ave., Suite 102 | Denver | CO | 80220 | WI |
| | Kent E. Harlan | 822 N. 7th St. | Beatrice | NE | 68310 | ORRI |
| | Debora A. Waymire | 5325 W. Kerry Lane | Glendale | AZ | 85308 | ORRI |
| | Pamela H. Wilson | 644 S. Griffith Park Dr. | Burbank | CA | 91506 | ORRI |
| | Todd D. Harlan | 319 Walnut St. | Hickman | NE | 68372 | ORRI |
| | BFG Minerals, LLC | 225 S. Broadway, Suite 9847 | Denver | CO | 80209 | MI |
| | Principle Energy, L.L.C. | P.O. Box 2228 | Houston | TX | 77252 | MI |
| | Pearlene Hawkins | 470A 2nd St. SW | Albuquerque | NM | 87105 | MI |
| | Faris Hawkins | 2275 Squak Mountain Loop SW | Issaquah | WA | 98027 | MI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | WI |
| | Donna M. Ford as Trustee of the Gary R. Ford and Donna M. Ford Revocable Trust, dated August 26, 2005 | 3840 SR 209 | Boroadview | NM | 88112 | MI |
| | Bert J. Farris | 3931 Granite Street | Cheyenne | WY | 82001 | MI |
| | Joleen Springer | 6241 Donnington Court | Sarasota | FL | 34238 | MI |
| | Lincoln Energy Partners IV, LLC | 3400 S. Broadway, Suite 100 | Englewood | CO | 80113 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Lost River Trading Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | J15, LLC | P.O. Box 31749 | Palm Beach Gardens | FL | 33420 | MI |
| | SAG Ag, LLC | 58710 County Road 81 | Grover | CO | 80729 | SI |
| | James M. Konig | 57851 WCR 81 | Grover | CO | 80729 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | Michael D. Konig | 58710 County Road 81 | Grover | CO | 80729 | MI |
| | Kip A. Konig | 51823 WCR 73 | Briggsdale | CO | 80611 | MI |
| | Joel W. Konig | 37231 Highway 14 | Briggsdale | CO | 80611 | MI |
| | Merlyn Charles Faris | Unknown Address | | | | MI |
| | Richard Leigh Faris | 431 Camino De Grato | Sparks | NV | 89441 | MI |
| | Jack Faris | Unknown Address | | | | MI |
| | Judy Likwartz | 5916 N. Wilbur Ave. | Portland | OR | 97217 | MI |
| | Todd Alan Martin and Sydnee Marie Martin as Co-Trustees of the Todd Alan Martin and Sydnee Marie Martin Marital Trust u/t/a dated 11-21-2019 | 169 County Road 148 | Carpenter | WY | 82054 | SI |
| | Bluebird Energy Partners, LLC | 9055 E. Mineral Circle, Suite 110 | Centennial | CO | 80112 | MI |
| | David Lindsey Kirchgessner | 13113 Orienta Avenue NE | Albuquerque | NM | 87123 | MI |
| | Thomas Winter Kirchgessner | 10404 Griffon Drive NW | Albuquerque | NM | 87114 | MI |
| | Laura Lee Bates | 12229 Yellowstone Road NE | Albuquerque | NM | 87111 | MI |
| | Highpoint Operating Corporation | 555 17th Street, Suite 3700 | Denver | CO | 80202 | MI / WI |
| | JP Morgan Chase Bank, N.A. | 1125 17th St., Floor 2 | Denver | CO | 80202 | MTG |
| | Raisa II, LLC | 1560 Broadway, Suite 250 | Denver | CO | 80202 | WI |
| | Kyle W. Breeden | 149 County Road 143 | Carpenter | WY | 82054 | MI |
| | Misty D. Balls | P.O. Box 70 | Fielding | UT | 84311 | MI |
| | Zachary Gleit, Trustee of the Roberta Gleit Revocable Trust dated February 24, 2018 | 755 West End Ave. #6C | New York | NY | 10025 | MI |
| T13N - R62W<br>Sec. 19: NE | Charlene K. Gordon and John G. Gordon | 796 Road 154 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Farm Credit Services of America, FLCA | 5015 S. 118th Street | Omaha | NE | 68103-2409 | MTG |
| T13N - R62W<br>Sec. 19: Lots 1, 2, E2NW | Ivan L. Kranz and Kimberly K. Kranz Joint Rev Trust | P.O. Box 129 | Burns | WY | 82053 | SI |
| | Lorraine Smith | 4696 CR 204 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R62W<br>Sec. 19: Lots 3, 4, E2SW | Lucinda I. Smith | 4890 CR 205 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R62W<br>Sec. 19: SE | Edwin K. Smith, Jr. and Lucinda I. Smith, husband and wife | 4890 CR 205 | Carpenter | WY | 82054 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R62W<br>Sec. 30: NE | Earl Eugene Noel & Donna C. Noel | P.O. Box 639 | Martin | SD | 57551 | SI |
| | Donna Rogers and Jeffrey Douglas | 707 S. Table Mountain Loop | Cheyenne | WY | 82009 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | The State Highway Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 | ROW |
| | Rampike Resources, Ltd. | 730 17th Street, Suite 370 | Denver | CO | 80202 | MI |
| | TRP Minerals, LLC | 4545 Post Oak Place, Suite 240 | Houston | TX | 70277 | MI |
| | Exodus Energy, LLC | 1474 S. Saint Paul St. | Denver | CO | 80210 | MI |
| | CECO, LLC | P.O. Box 102076 | Denver | CO | 80250 | MI |
| T13N - R62W<br>Sec. 30: Lots 1, 2, E2NW | Oscar E. Orozco and Michelle M. Orozco | 4807 Road 205 | Carpenter | WY | 82054 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | The State Highway Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 | ROW |
| | Kathleen Kay Arp Woolbright | 311 S. Tennessee St. | Amarillo | TX | 79106 | MI |
| | Adrian Lynn Arp | P.O. Box 703 | Filer | ID | 83328 | MI |
| | Gregory Gene Arp | Box 332 | Bennet | NE | 68317 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R62W<br>Sec. 30: Lots 3, 4, E2SW | Gary R and Donna M. Ford Revocable Trust | 3840 SR 209 | Broadview | NM | 88112 | SI / MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | The State Highway Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R62W<br>Sec. 30: SE | Gary R and Donna M. Ford Revocable Trust | 3840 SR 209 | Broadview | NM | 88112 | SI / MI |
| | Donna Rogers and Jeffrey Douglas | 707 S. Table Mountain Loop | Cheyenne | WY | 82009 | SI |
| | Rampike Resources, Ltd. | 730 17th Street, Suite 370 | Denver | CO | 80202 | MI |
| | TRP Minerals, LLC | 4545 Post Oak Place, Suite 240 | Houston | TX | 70277 | MI |
| | Exodus Energy, LLC | 1474 S. Saint Paul St. | Denver | CO | 80210 | MI |
| | CECO, LLC | P.O. Box 102076 | Denver | CO | 80250 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | The State Highway Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 | ROW |
| T13N - R62W<br>Sec. 31: NE | Richard R. Whited Living Trust | 3670 Columbia Falls Stage | Columbia Falls | MT | 59912 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | MI / ROW |
| | State of Wyoming<br>Office of State Lands & Investments | Herschler Building<br>122 W. 25th Street - W103 | Cheyenne | WY | 82002 | ROW |
| T13N - R62W<br>Sec. 31: Lots 1, 2, E2NW | Gary R and Donna M. Ford Revocable Trust | 3840 SR 209 | Broadview | NM | 88112 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | MI / ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| T13N - R62W<br>Sec. 31: Lots 3, 4, E2SW | Joshua C. Rohde | 4834 Road 203 | Carpenter | WY | 82054 | SI |
| | Anadarko Land Corp., a Nebraska corporation, formerly Union Pacific Land Resources Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | ROW |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Roger Jewell | 4853 Monroe Ave | Carpenter | WY | 82054 | SI |
| | Roger Jewell | 4857 Monroe Ave | Carpenter | WY | 82054 | SI |
| | Dennis J Seidl | 4846 Monroe Ave | Carpenter | WY | 82054 | SI |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Evergreen Pipeline, Inc | 4842 Road 203 | Carpenter | WY | 82054 | SI |
| | Cory Morgan and Heather Morgan | 313 2nd Street | Carpenter | WY | 82054 | SI |
| | Scott Morgan and Denise Morgan | 312 2nd St. | Carpenter | WY | 82054 | SI |
| | Jeffrey E. Spence Revocable Trust | 4816 Road 203 | Carpenter | WY | 82054 | SI |
| | Carpenter Cemetery | Road 204 | Carpenter | WY | 82054 | SI |
| | Grace Valley, LLC | 316 E. 1st Street | Carpenter | WY | 82054 | SI |
| | In God We Trust No 1 Revocable Trust<br>In God We Trust No 2 Revocable Trust | 324 County Road 148 | Carpenter | WY | 82054 | SI |
| | Jason W. Smith and Lisa J. Smith | P.O. Box 401 | Carpenter | WY | 82054 | SI |
| | Laramie County School District No. 2 | 4814 Monroe Ave | Carpenter | WY | 82054 | SI |
| | Kristy Jean McKinney | 348 N 1st St. | Carpenter | WY | 82054 | SI |
| | Donald A. Syvanen and Mary Ann Syvanen | P.O. Box 472 | Carpenter | WY | 82054 | SI |
| | Kathy Marie Hammons | 4840 Adams Ave. | Carpenter | WY | 82054 | SI |
| | Cassandra Carroll, c/o Lindvall Neil | 4838 Monroe Avenue | Carpenter | WY | 82054 | SI |
| | Cassandra Carroll, c/o Lindvall Neil | 208 E. Prosser Rd. | Cheyenne | WY | 82007 | SI |
| | Karen Ankers | 4836 Monroe Avenue | Carpenter | WY | 82054 | SI |
| | Carol M. Bradley Living Trust | 1951 Fern Court | Kissimmee | FL | 34743 | SI |
| | Jerry L. Burnett and Margaret E. Burnett | P.O. Box 4 | Hereford | CO | 80732 | SI |
| | Burnett Land & Livestock, Ltd. | 5453 County Road 202 | Carpenter | WY | 82054 | SI |
| | Jerry L. Burnett and Margaret E. Burnett | 4834 Monroe Avenue | Carpenter | WY | 82054 | SI |
| | James Michael Morris | 2121 Redhead Dr | Johnstown | CO | 80534 | SI |
| | Russell D. Matz and Bettyanne M. Haines | 4831 Monroe Avenue | Carpenter | WY | 82054 | SI |
| | Don S. Poelma and Gayle L. Poelma | 6515 Armant Ct | Cheyenne | WY | 82009 | SI |
| | Joyce P. Andrews | 4825 Monroe Avenue | Carpenter | WY | 82054 | SI |
| | Jon J. Dalton | 335 N 1st | Carpenter | WY | 82054 | SI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Mark E. Goehring and Karen J. Goehring | 336 N 1st | Carpenter | WY | 82054 | SI |
| | Carpenter Christian Fellowship Church | 4858 Adams Ave | Carpenter | WY | 82054 | SI |
| | Ezra Derstine c/o Matthew Derstine | 331 Second Street | Carpenter | WY | 82054 | SI |
| | Lynn Warner, Matthew Yoder and Janel Yoder | 332 3rd Street | Carpenter | WY | 82054 | SI |
| | Evans Community Park | P.O. Box O | Carpenter | WY | 82054 | SI |
| | St Peters Church | 316 4th Street | Carpenter | WY | 82054 | SI |
| | David J. Leastman and Lorayne A. Leastman | 4849 E. Adams Avenue | Carpenter | WY | 82054 | SI |
| | Marcia Lea Leastman | 4845 E. Adams Avenue | Carpenter | WY | 82054 | SI |
| | John Ferrera | 4833 Adams Avenue | Carpenter | WY | 82054 | SI |
| | Billy Nokes and Emily Nokes | 315 2nd Street | Carpenter | WY | 82054 | SI |
| | Cory Morgan and Heather Morgan | 313 2nd Street | Carpenter | WY | 82054 | SI |
| | Scott Morgan and Denise Morgan | 313 2nd Street | Carpenter | WY | 82054 | SI |
| | Leo Smith and Janet Smith | 115 Road 153 | Carpenter | WY | 82054 | SI |
| | Todd Alan Martin and Sydnee Marie Martin as Co-Trustees of the Todd Alan Martin and Sydnee Marie Martin Marital Trust u/t/a dated 11-21-2019 | 169 County Road 148 | Carpenter | WY | 82054 | SI |
| | Roberta Lee May | 1251 Road 7 | Pine Bluffs | WY | 82082 | SI |
| | Carpenter Water and Sewer District | P.O. Box 433 | Carpenter | WY | 82054 | SI |
| | Scott Thums and Elizabeth Thums | P.O. Box 372 | Carpenter | WY | 82054 | SI |
| | Marvin K. Stuart and Larita P. Stuart | 326 2nd St | Carpenter | WY | 82054 | SI |
| | Leona I Price | P.O. Box 161 | Burns | WY | 82053 | SI |
| | J.R. Carpenter c/o Evans Park Board | P.O. Box 5 | Carpenter | WY | 82054 | SI |
| | Laramie County Fire Protection Dist 4 | P.O. Box 5 | Carpenter | WY | 82054 | SI |
| | Paul M. Gonzales and Erin M. Gonzales | 4821 Main Ave. | Carpenter | WY | 82054 | SI |
| | Lonnie D. Fiscus and Marjorie A. Fiscus | 4834 Main Street | Carpenter | WY | 82054 | SI |
| | Reese Burnett and Hannah Burnett | 4840 Adams Ave. | Carpenter | WY | 82054 | SI |
| | Larry Williams, Penny E. Martin and Vera E. Williams | 4832 Adams Ave | Carpenter | WY | 82054 | SI |
| | Blaine W. Barker | 4834 Adams Ave | Carpenter | WY | 82054 | SI |
| | Kevin J. Dobbs and Jami L. Dobbs | 324 Main Street | Carpenter | WY | 82054 | SI |
| | Ruby Pearl True | Unknown Address | | | | SI |
| | Cheyenne Light, Fuel and Power Company | P.O. Box 1409 | Cheyenne | WY | 82003 | ROW |
| | The Mountain States Telephone and Telegraph Company | 931 14th Street | Denver | CO | 80202 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | New West Bank | 55 S Elm Avenue | Eaton | CO | 80615 | MTG |
| | Larry J. Lembitz and Diana L. Lembitz | Unknown Address | | | | SI |
| | Rural Electric Company, a Cooperative | 2312 Carey Avenue | Cheyenne | WY | 82001-3627 | ROW |
| T13N - R62W<br>Sec. 31: SE | Richard R. Whited Living Trust | 3670 Columbia Falls Stage | Columbia Falls | MT | 59912 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Union Pacific Resources Company | P.O. Box 7, MS 3300 | Fort Worth | TX | 76101 | ROW |
| | Leo Smith and Janet Smith | 115 Road 153 | Carpenter | WY | 82054 | SI |
| | Dennis J Seidl | 4846 Monroe Ave | Carpenter | WY | 82054 | SI |
| | David John Leastman II and Regina Raye Leastman | 320 5th Street | Carpenter | WY | 82054 | SI |
| | David J. Leastman and Lorayne A. Leastman | 4849 E. Adams Avenue | Carpenter | WY | 82054 | SI |
| | John A. Barela Revocable Trust | 314 5th St | Carpenter | WY | 82054 | SI |
| | Evergreen Pipeline, Inc | 4842 Road 203 | Carpenter | WY | 82054 | SI |
| | The Transportation Commission of Wyoming | 5300 Bishop Blvd. | Cheyenne | WY | 82009 | ROW |
| | State of Wyoming<br>Office of State Lands & Investments | Herschler Building<br>122 W. 25th Street - W103 | Cheyenne | WY | 82002 | ROW |
| | The Mountain States Telephone and Telegraph Company | 931 14th Street | Denver | CO | 80202 | ROW |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| T13N - R63W<br>Sec. 14: S2 | Carol M. Bradley Living Trust | 1951 Fern Court | Kissimmee | FL | 34743 | SI |
| | 293Frog, LLC | 7551 Bocage Boulevard | Baton Rouge | LA | 70809 | MI |
| | Charles W. Austin | P.O. Box 1153 | Billings | MT | 59103 | MI |
| | T. F. Hodge | 1605 Continental Bank Building | Fort Worth | TX | 76102 | MI |
| | ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 | MI |
| | Jill Jahn, aka Jill Tower aka Jill F. Tower | P.O. Box 156 | Fishtail | MT | 59222 | MI |
| | Keith Tower and Martha J. Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 | MI |
| | Alice G. Tower | 2434 Rancho Road | Billings | MT | 59102 | MI |
| | Shandera3, LLC | 3733 Gunsmoke Road | Cheyenne | WY | 82001 | MI |
| | Rodney E. and Sylvia M. Girmus | 7067 Road 47F | Torrington | WY | 82240 | MI |
| | Bryon P. and Peggy A. Veal | 5855 East 124th | Brighton | CO | 80601 | MI |
| | Mark C. and Laura E. Anzman, Co-Trustees of the Mark and Laura Anzman Living Trust, dated 5/8/2013 | 4655 County Road 207 | Carpenter | WY | 82054 | MI |
| | Cox Minerals LLC | P.O. Box 2015 | Billings | MT | 59103-2015 | MI |
| | Raymond L. and Diana L. Martin | 4691 County Road 207 | Carpenter | WY | 82054 | MI |
| | Sharon K. Miller and Brent L (Nidelkoff) Piscitello | 1722 Cheshire Drive | Cheyenne | WY | 82001 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Michael Schreiner, Successor Trustee of the Lois M. Schreiner Trust Agreement, dated 7/25/2006 | 416 Cody | Cheyenne | WY | 82009 | MI |
| | Gary A. Weber and Christine D. Weber | 4619 County Road 207 | Carpenter | WY | 82054 | MI |
| | Maureen J. Shandera, Trustee of the Maureen J. Shandera Revocable Trust, dated 5/20/1998 | 5192 Road 207 | Carpenter | WY | 82054 | MI |
| | Sherry Cox Dupee | 105 Fair Acres Road | Oxford | England | OX4 - 1 TQ | MI |
| | Harold V. Stroot and Cynthia K. Stroot | P.O. Box 76 | Burns | WY | 82053 | MI |
| | Maxine B. Morgan | 8310 Heather Avenue | Eden Prairie | MN | 55347 | MI |
| | Jeffery W. Hamel | 8310 Heather Avenue | Eden Prairie | MN | 55347 | MI |
| | B. Frank Brady | Unknown Address | | | | MI |
| | Cynthia K. and Harold V. Stroot | Unknown Address | | | | MI |
| | Janice Ann Taylor aka Jan Taylor aka Janice A. Taylor | 636 E. Magnesium Rd. Apt C-111 | Spokane | WA | 99208 | MI |
| | Ralph V. Kent | Unknown Address | | | | MI |
| | Howard and Elsie Rose Evans | Unknown Address | | | | MI |
| | Virginia G. Newman | Unknown Address | | | | MI |
| | Jimmy Lee Alexander | P.O. Box 178 | Kingfisher | OK | 73750 | MI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Renegade Resources, LLC c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| T13N - R63W<br>Sec. 15: All | Shawn P. and Brandi Halls | 1708 County Road 136 | Cheyenne | WY | 82009 | SI |
| | Patricia A and Peter C. Gassner, Jr. | 4567 County Road 207 | Carpenter | WY | 82054 | SI |
| | Craig and Alaina Goble | 1480 Gilchrist Road | Cheyenne | WY | 82009 | SI |
| | Red Baldy Ranch | 785 Road 140 | Carpenter | WY | 82054 | SI |
| | Martin Wissner, Trustee, and his successor in trust, under the Martin Wissner Living Trust, dated 5/31/2019, for the benefit of Martin Wissner and his heirs | 620 Road 146 | Carpenter | WY | 82054 | SI |
| | Jeremy Russell and Tanya Marie Evans | 5680 Road 228 | Albin | WY | 82050 | SI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Phillip M. Brandt and Lorraine S. Brandt | 3153 Bluff Place | Cheyenne | WY | 82009 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Thomas S. Harrower, Jr. | 8603 Powderhouse Road | Cheyenne | WY | 82009 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Farm Service Agency | 1502 Progress Court | Wheatland | WY | 82201 | MTG |
| | Bank of the West | 2200 East Lincoln Way | Cheyenne | WY | 82001 | MTG |
| | Meridian Trust Federal Credit Union | P.O. Box 548 | Cheyenne | WY | 82003 | MTG |
| | Jonah Bank of Wyoming | 777 West 1st Street | Casper | WY | 82601 | MTG |
| | Platte Valley Bank | 421 Vandehei Avenue | Cheyenne | WY | 82009-6103 | MTG |
| T13N - R63W<br>Sec. 20: All | Michael W. and Dorothy M. Anthony | 595 County Road 143 | Carpenter | WY | 82054 | SI |
| | Terry L. Nachtman | 581 Road 143 | Carpenter | WY | 82054 | SI |
| | Harrower Ranches LLC | 8603 Powderhouse Road | Cheyenne | WY | 82009 | SI / MI |
| | Joseph and Allison Ward | 535 Road 143 | Carpenter | WY | 82054 | SI |
| | United States of America / Bureau of Land Management | 5353 Yellowstone Road | Cheyenne | WY | 82009 | MI |
| | Lillian E. Harrower Revocable Mineral Trust, dated 11/2/2007 | 8603 Powderhouse Road | Cheyenne | WY | 82009 | MI |
| | Mary Christine Dorr and Susan Lee Snyder | Unknown Address | | | | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Trading River Trading Company | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Raymond Z. and Mildred E. Nolt | 535 Road 143 | Carpenter | WY | 82054 | MI |
| | AK Resources, LLC | P.O. Box 6975 | Denver | CO | 80206 | MI |
| | ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 | MI |
| | Jill Jahn, aka Jill Tower aka Jill F. Tower | P.O. Box 156 | Fishtail | MT | 59222 | MI |
| | Keith Tower and Martha J. Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 | MI |
| | Lincoln Energy Partners, LLC | 852 Broadway, Suite 300 | Denver | CO | 80203 | MI |
| | Community Investments, Inc. | P.O. Box 653 | Cheyenne | WY | 82003 | MI |
| | Zora N. Montgomery | 816 South 216th Street, T311 | Des Moines | WA | 98198 | MI |
| | Gene E. Miller | P.O. Box 68 | Chappell | NE | 69129 | MI |
| | Terry L. Nachtman | 581 Road 143 | Carpenter | WY | 82054 | MI |
| | 293Frog, LLC | 7551 Bocage Boulevard | Baton Rouge | LA | 70809 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Harrower Ranches LLC | 8603 Powderhouse Road | Cheyenne | WY | 82054 | MI |
| | BEIF #2, LLC | 475 17th Street, Suite 570 | Denver | CO | 80202 | MI |
| | John S. Belcher, LLC | 235 South High Street | Denver | CO | 80209 | MI |
| | Michael W. and Dorothy M. Anthony | 595 County Road 143 | Carpenter | WY | 82054 | MI |
| | Cox Minerals LLC | P.O. Box 2015 | Billings | MT | 59103-2015 | MI |
| | Sherry Cox Dupee | 105 Fair Acres Road | Oxford | England | OX4 - 1 TQ | MI |
| | Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Lost River Trading Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Lillian E. Harrower Revocable Mineral Trust, dated 11/2/2007 | 8603 Powderhouse Road | Cheyenne | WY | 82009 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Production Credit Association of the Midlands | P.O. Box J | Torrington | WY | 82240 | MTG |
| | First Interstate Bank | P.O. Box 1098 | Torrington | WY | 82240 | MTG |
| | Freedom Mortgage Corporation | 951 Yamoto Road, Suite 175 | Boca Raton | FL | 33431 | MTG |
| T13N - R63W<br>Sec. 21: All | Harrower Ranches LLC | 8603 Powderhouse Road | Cheyenne | WY | 82009 | SI / MI |
| | Robert Gin and Rebekah Tan, Trustees of The Tan-Gin Family Trust, dated 9/1/2004 | 2568 West Overton Ridge Place | Tucson | AZ | 85742 | SI |
| | Jerry E. and Roxie C. Anderson | 4455 Teepee Road | Carpenter | WY | 82054-9109 | SI |
| | Michael R. Calaway and Vickie L. Hintze | 4487 Teepee Road | Carpenter | WY | 82054 | SI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Phillip M. Brandt and Lorraine S. Brandt | 3153 Bluff Place | Cheyenne | WY | 82009 | MI |
| | Gene E. Miller | P.O. Box 68 | Chappell | NE | 69129 | MI |
| | Janet Iokepa | 415 Keonaona Street | Hilo | HI | 96720 | MI |
| | Heather Montgomery | 3907 East 12th | Spokane | WA | 99202 | MI |
| | Jared Montgomery | 3907 East 12th | Spokane | WA | 99202 | MI |
| | Keith E. Montgomery | 305 Ave A | Battle Creek | MI | 49015 | MI |
| | Susan Olson-Miller | Unknown Address | | | | MI |
| | Martin Jacob Miller | Unknown Address | | | | MI |
| | Amanda Jo Miller- McClanahan | Unknown Address | | | | MI |
| | BHCH Mineral, Ltd. | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Fredericksburg Royalty, Ltd | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Curzon Management, LLC | 1116 Wiltshire Avenue | San Antonio | TX | 78209 | MI |
| | Anadarko Oil & Gas 5, LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Thomas Harrower, Jr. and Lillian Harrower | 8603 Powderhouse Road | Cheyenne | WY | 82009 | ROW |
| | Western Vistas FCU | 3207 Sparks Road | Cheyenne | WY | 82001 | MTG |
| T13N - R63W<br>Sec. 22: All | Roy V. and Linda L. Beaver | 1104 Maddison Avenue | Cheyenne | WY | 82001 | SI |
| | Jonea R. Fuller and James L. Fuller | 285 Crossbow Dr | Green River | WY | 82935 | SI |
| | Marilyn K. Machay c/o Marilyn K. Detillion | 7004 Denise Road | Cheyenne | WY | 82009 | SI |
| | Jeffery L. and Melissa A. Matney | 4514 Teepee Road | Carpenter | WY | 82054 | SI |
| | Nicole and Richard Lorh | 4507 Teepee Road | Carpenter | WY | 82054 | SI |
| | Dallas C. Harrigfeld | P.O. Box 20303 | Cheyenne | WY | 82003 | SI |
| | Cody E. and Laura Jo Howes | 4566 Buggy Road | Carpenter | WY | 82054 | SI |
| | Justin A. and Karen A. Morrison | 512 Road 146 | Carpenter | WY | 82054 | SI |
| | Joanne E. Brown-Vossler | 1030 Washington Street | Douglas | WY | 82633 | SI |
| | Jason and Mona Castle | 4528 Buggy Road | Carpenter | WY | 82054 | SI |
| | Sage Farms, LLC | 1595 Tanaka Drive | Erie | CO | 80516 | SI / MI |
| | Larry E. Seitz M.D., Trustee of the Larry E. Seitz Revocable Trust, dated 3/11/1981 | 219 Palm Springs Avenueast | Cheyenne | WY | 82009 | SI / MI |
| | Christopher H. and Amy Lynn Clark | 4533 Teepee Road | Carpenter | WY | 82054 | SI / MI |
| | Roger N. and Eddy Linda Stearns | 4539 Buggy Road | Carpenter | WY | 82054 | SI / MI |
| | Maureen T. Moore | 4511 Buggy Road | Carpenter | WY | 82054 | SI / MI |
| | Cox Minerals LLC | P.O. Box 2015 | Billings | MT | 59103 | MI |
| | BHCH Mineral, Ltd. | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Fredericksburg Royalty, Ltd | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Curzon Management, LLC | 1116 Wiltshire Avenue | San Antonio | TX | 78209 | MI |
| | Nicole and Richard Lorh | 4507 Teepee Road | Carpenter | WY | 82054 | MI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | MI |
| | Renegade Exploration, LLC | 1625 Broadway, Suite 830 | Denver | CO | 80202 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | 293Frog, LLC | 7551 Bocage Boulevard | Baton Rouge | LA | 70809 | MI |
| | ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 | MI |
| | Jill Jahn, aka Jill Tower aka Jill F. Tower | P.O. Box 156 | Fishtail | MT | 59222 | MI |
| | Keith Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 | MI |
| | Janice Ann Taylor aka Jan Taylor aka Janice A. Taylor | 636 E. Magnesium Rd. Apt C-111 | Spokane | WA | 99208 | MI |
| | Ross M. Taylor | 34752 Bachelor Flat Road | St. Helens | OR | 97051 | MI |
| | Kimberly T. Dunn | 2631 W. Dell Drive | Spokane | WA | 99208 | MI |
| | Sherry Cox Dupee | 105 Fair Acres Road | Oxford | England | OX4 - 1 TQ | MI |
| | Harrower Ranches LLC | 8603 Powderhouse Road | Cheyenne | WY | 82009 | MI |
| | Charles Y. Lu and Felice S. Huang | P.O. Box 20303 | Cheyenne | WY | 82303 | MI |
| | Jeffrey L. and Melissa A. Matney | 4514 Teepee Road | Carpenter | WY | 82054 | MI |
| | John and Mona Castle | 4528 Buggy Road | Carpenter | WY | 82054 | MI |
| | J. E. Taylor | 1925 Grand Avenue | Billings | MT | 59102 | MI |
| | Charles W. Austin | P.O. Box 1153 | Billings | MT | 59103 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Donald A. and Stacy L. Edgar | 17892 Bagby Road | Green Ridge | MO | 65332 | MI |
| | Cody E. and Laura Jo Howes | 9039 South Greenspoint Lane | Highlands Ranch | CO | 80130 | MI |
| | Wyoming Bank & Trust | 5827 Yellowstone Road | Cheyenne | WY | 82009 | MI |
| | Justin A. and Karen A. Morrison | 512 Road 146 | Carpenter | WY | 82054 | MI |
| | Robert P. Korber Revocable Trust | 1725 Eagle Drive | Cheyenne | WY | 82009 | MI |
| | Jeffery C. and Danielle D. Hackett | 4566 Buggy Road | Carpenter | WY | 82054 | MI |
| | Alice Jones | Unknown Address | | | | MI |
| | Linda Edgar | Unknown Address | | | | MI |
| | Roseshell A. Ward | Unknown Address | | | | MI |
| | Cassandra J. Ward | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Charlotte L. Sharp | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Manuel Blanco, IIII | Unknown Address | | | | MI |
| | Ruth M. and John P. Rome | 6516 Hedge Lane Terrace, Apt. # 106 | Shawnee | KS | 66226 | MI |
| | Charles Edgar | Unknown Address | | | | MI |
| | Ruth Enfield Edgar | Unknown Address | | | | MI |
| | Misty Tinney & Roy V. Beaver, Jr. | Unknown Address | | | | MI |
| | Mary Christine Dorr and Susan Lee Snyder | Unknown Address | | | | MI |
| | Joanne E. Brown-Vossler | 1030 Washington Street | Douglas | WY | 82633 | MI |
| | Roger N. and Eddy Linda Stearns | 4539 Buggy Road | Carpenter | WY | 82054 | MI |
| | Janet F. Hetzel | 37174 County Road 124 | Grover | CO | 80729 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Thomas S. Harrower, Jr. | 8603 Powderhouse Road | Cheyenne | WY | 82009 | ROW |
| | Guild Mortgage Company | 5898 Copley Drive | San Diego | CA | 92111 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | UniWyo Federal Credit Union | 2020 E. Grand Avenue, Suite 100 | Laramie | WY | 82070 | MTG |
| | Blue Federal Credit Union | P.O. Box 3200 | Cheyenne | WY | 82003 | MTG |
| | United Wholesale Mortgage, LLC | 585 South Boulevard E | Pontiac | MI | 48341 | MTG |
| | First Interstate Bank | 401 W. 9th Street | Cheyenne | WY | 82001 | MTG |
| | Wells Fargo Bank , N.A. | P.O. Box 11701 | Newark | NJ | 07101-4701 | MTG |
| | Wyoming Community Development Authority | 155 North Beech | Casper | WY | 82602 | MTG |
| T13N - R63W<br>Sec. 23: All | Travis and Christy Wilson | 4661 Road 206 | Carpenter | WY | 82054 | SI |
| | Mahegge, LLC | P.O. Box 1416 | Mills | WY | 82644 | SI |
| | Caldwell Banker The Property Exchange | 255 Storey Boulevard | Cheyenne | WY | 82009 | SI |
| | Leaning Tree Homes, Inc. | 1740 Dell Range Boulevard, Suite 423 | Cheyenne | WY | 82009 | SI |
| | Randy Lynn and Victoria Lynn Ackerman | 6519 Kyle Avenue | Fort Collins | CO | 80525 | SI |
| | Kevin and Lynn Emery | 4613 Road 206 | Carpenter | WY | 82054 | SI |
| | Marie E. Bachofer | 4643 Road 206 | Carpenter | WY | 82054 | SI / MI |
| | Stanley D. and Jennifer L. Baer | 4644 Road 204 | Carpenter | WY | 82054 | SI |
| | Leroy and Marilyn Wiens | 511 Road 146 | Carpenter | WY | 82054 | SI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Max E. True and Judy V. True | 4625 County Road 206 | Carpenter | WY | 82054 | MI |
| | Bulldog Energy , LLC | 2460 W. Caithness Place, Unit 207 | Denver | CO | 80211 | MI |
| | Westland Holdings, Inc. | P.O. Box 653 | Cheyenne | WY | 82003 | MI |
| | Rearden Minerals, LLC | 5914 W. Courtyard Drive | Austin | TX | 78730 | MI |
| | Acoma Energy, LLC | 3801 E. Florida Avenue, Suite 508 | Denver | CO | 80210 | MI |
| | TAPS I Energy, LLC | 1001 Farmington Avenue, Suite 200 | West Hartford | CT | 06107 | MI |
| | Beth and Ken Karmin Family Trust | 1555 Capri Drive | Pacific Palasades | CA | 90272 | MI |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Quicken Loans, LLC | 1050 Woodward Avenue | Detroit | MI | 48226-1906 | MTG |
| | Cherry Creek Mortgage, LLC | 7600 East Orchard Road, Suite #250-N | Greenwood Village | CO | 80111 | MTG |
| | First Interstate Bank | P.O. Box 1710 | Cheyenne | WY | 82001-1710 | MTG |
| T13N - R63W<br>Sec. 24: All | M&P Concrete, Inc. | P.O. Box 2096 | Cheyenne | WY | 82003 | SI |
| | Burdine W. Rogers, Jr. | 4771 Road 206 | Carpenter | WY | 82054 | SI |
| | Anthony Haar and Sheralee Clark | 4765 Road 206 | Carpenter | WY | 82054 | SI |
| | Jeffery William and Daniella LeNea Allman | 4761 Road 206 | Carpenter | WY | 82054 | SI / MI |
| | Linda L. Lankford | 4573 Road 206 | Carpenter | WY | 82054 | SI |
| | G & G Enterprises of WY, LLC | 255 Storey Boulevard | Cheyenne | WY | 82009 | SI |
| | Leaning Tree Homes, Inc. | 1740 Dell Range Boulevard, Suite 423 | Cheyenne | WY | 82009 | SI |
| | Richard Philip and Leanne Vannaman | 3337 Alexander Avenue | Cheyenne | WY | 82001 | SI |
| | Charles Y. Lu and Felice S. Huang | P.O. Box 20303 | Cheyenne | WY | 82003 | SI |
| | Mahegge, LLC | P.O. Box 1416 | Mills | WY | 82644 | SI |
| | Keke Lu and Yong Cao | 6 Myrtle Dr | Acton | MA | 01720 | SI |
| | JKW, LLC | 255 Storey Boulevard | Cheyenne | WY | 82009 | SI |
| | Abigail and Kevin Oblak | 5426 Sagebrush Avenue | Cheyenne | WY | 82009 | SI |
| | Maxine Soppe | P.O. Box 2778 | Cheyenne | WY | 82003 | SI |
| | David Bruce Soppe Living Trust | P.O. Box 4 | Kaycee | WY | 82639 | SI |
| | Burdine W. Rogers, Jr. | 4771 Road 206 | Carpenter | WY | 82054 | MI |
| | Arrow Energy, LLC | 809 W. 3rd Street | McCook | NE | 69001 | MI |
| | Gary and Karen McCallister | Unknown Address | | | | MI |
| | Weston Eugene Cochran | 609 Ash Street | Fort Morgan | CO | 80701 | MI |
| | M&P Concrete, Inc. | P.O. Box 2096 | Cheyenne | WY | 82003 | MI |
| | Grayrock Minerals, LLC | 5950 Cedar Springs Road, Suite 200 | Dallas | TX | 75235 | MI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | MI |
| | Mahegge, LLC | P.O. Box 1416 | Mills | WY | 82644 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Lost River Trading Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Arbor Mineral Company, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | Anthony Haar and Sheralee Clark | 4765 Road 206 | Carpenter | WY | 82054 | MI |
| | John Dean | P.O. Box 1028 | Gilmer | TX | 75644 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | John Scott Gibson and Judy A. Gibson | 16838 Morgan Road 10 | Fort Morgan | CO | 80701 | MI |
| | Linda L. Lankford | 4573 Road 206 | Carpenter | WY | 82054 | MI |
| | Maxine Soppe | 504 Road 148 | Carpenter | WY | 82054 | MI |
| | Lucinda I. Smith | 4890 CR 205 | Carpenter | WY | 82054 | MI |
| | Lorraine Smith | 4696 CR 204 | Carpenter | WY | 82054 | MI |
| | Mary Soppe | 5145 Clifford Avenue | Las Cruces | NM | 88012 | MI |
| | Michael Soppe | Unknown Address | | | | MI |
| | Lloyd W. Hammond | Unknown Address | | | | MI |
| | James A. Hammond | Unknown Address | | | | MI |
| | Mable O. Gustafson | Unknown Address | | | | MI |
| | Charles R. Hammond | Unknown Address | | | | MI |
| | Patricia Hammond | Unknown Address | | | | MI |
| | William Collicott, as PR for the Estate of Melvin L. Collicott | Unknown Address | | | | MI |
| | First Interstate Bank | P.O. Box 1710 | Cheyenne | WY | 82003-1710 | MTG |
| | WyHy Federal Credit Union | 1715 Stillwater Avenue | Cheyenne | WY | 82009 | MTG |
| | Rocket Mortgage, LLC fka Quicken Loans | 1050 Woodward Avenue | Detroit | MI | 48226-1906 | MTG |
| | Bank of America | 101 South Tryon Street | Charlotte | NC | 28255 | MTG |
| | Platte Valley Ag Credit Co. | P.O. Box 790 | Torrington | WY | 82240 | MTG |
| T13N-R63W<br>Sec. 25: All | Maxine Soppe | P.O. Box 2778 | Cheyenne | WY | 82003 | SI |
| | Jeff and Molly Williams Family Revocable Family Trust | 1418 E 21st Street | Cheyenne | WY | 82001 | SI |
| | Brenda Jo Millikin | 4727 Road 205 | Carpenter | WY | 82054 | SI |
| | Stanley D. and Jennifer L. Baer | 4644 Road 204 | Carpenter | WY | 82054 | SI |
| | Smith and Jones, LLC c/o Jimmy V. Jones | 678 Sand Castle Way | Mesquite | NV | 89027 | SI |
| | Gary Smith Family Living Trust | P.O. Box 26 | Hereford | CO | 80732 | SI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Smith & Jones, LLC | 6102 East Hwy 30 | Cheyenne | WY | 82001 | MI |
| | Mary Maxine Soppe | 504 Road 148 | Carpenter | WY | 82054 | MI |
| | Lucinda I. Smith | 4890 CR 205 | Carpenter | WY | 82054 | MI |
| | Lorraine Smith | 4696 CR 204 | Carpenter | WY | 82054 | MI |
| | Mary Soppe | 5145 Clifford Avenue | Las Cruces | NM | 88012 | MI |
| | David Soppe | P.O. Box 4 | Kaycee | WY | 82639 | MI |
| | Michael Soppe | Unknown Address | | | | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | Oneonta Resources, LLC | 5228 Lonetree Drive | Loveland | CO | 80537 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Anadarko Oil & Gas 5, LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | Border Resources, LLC | 5300 DTC Parkway, Suite 230 | Greenwood Village | CO | 80111 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Renegade Resources, LLC<br>c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| T13N - R63W<br>Sec. 26: All | Brenda Jo Millikin | 4727 Road 205 | Carpenter | WY | 82054 | SI / MI |
| | Stanley D. and Jennifer L. Baer | 4644 Road 204 | Carpenter | WY | 82054 | SI / MI |
| | Gary Smith Family Living Trust | P.O. Box 26 | Hereford | CO | 80732 | SI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Mary Maxine Soppe | 504 Road 148 | Carpenter | WY | 82054 | MI |
| | Lucinda I. Smith | 4890 CR 205 | Carpenter | WY | 82054 | MI |
| | Lorraine Smith | 4696 CR 204 | Carpenter | WY | 82054 | MI |
| | Mary Soppe | 5145 Clifford Avenue | Las Cruces | NM | 88012 | MI |
| | David Soppe | P.O. Box 4 | Kaycee | WY | 82639 | MI |
| | Michael Soppe | Unknown Address | | | | MI |
| | Arrow Energy, LLC | 809 W. 3rd Street | McCook | NE | 69001 | MI |
| | Oneonta Resources, LLC | 5228 Lonetree Drive | Loveland | CO | 80537 | MI |
| | Thomas W. Stagg | 1309 Ironwood Street | Boulder City | NV | 89004 | MI |
| | Mark R. Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | David F. Stagg | 9609 239th Street North | Port Byron | IL | 61275 | MI |
| | Elenor Stagg King | P.O. Box 3033 | Clinton | IA | 52732 | MI |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | ORRI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Laramie Operating LLC, a Colorado limited liability company | 1120 Lincoln Street, Suite 1605 | Denver | CO | 80203 | WI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | WI |
| | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | WI |
| | Faith Partners Land Company, LLC | 4772 Tara Ct. | West Bloomfield | MI | 48323 | WI |
| | WYDJ ORI Investments I, LLC | P.O. Box 460868 | Denver | CO | 80246 | ORRI |
| | WYDJ Energy LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | ROW |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | ROW |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Wyoming Bank & Trust | 5827 Yellowstone Road | Cheyenne | WY | 82009 | MTG |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| T13N - R63W | Sharon E. Hayes Revocable Trust | 18821 Freemont Avenue North | Shoreline | WA | 98133 | SI / MI |
| Sec. 27: All | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Acoma Energy, LLC | 3801 E. Florida Avenue, Suite 508 | Denver | CO | 80210 | MI |
| | Beauleo Minerals, LLC | 5 Brighton Way | Farmington | CT | 06032 | MI |
| | Beth and Ken Karmin Family Trust | 1555 Capri Drive | Pacific Palasades | CA | 90272 | MI |
| | Fossil Creek Land Company | P.O. Box 485 | Mustang | OK | 73064 | MI |
| | Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 | MI |
| | The Greg & Nancy Vance Family Limited Partnership c/o Production Gathering Company, LP | 8080 N. Central Expressway, Suite 1090 | Dallas | TX | 75206 | MI |
| | Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 | MI |
| | Hydrocarbon Minerals II, LLC | P.O. Box 2157 | Bridgeview | IL | 60455 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | John Scott Gibson and Judy A. Gibson | 16838 Morgan Road 10 | Fort Morgan | CO | 80701 | MI |
| | MA - Minerals LLC | P.O. Box 3759 | Manhattan Beach | CA | 90266 | MI |
| | HOG BG, LLC | P.O. Box 526412 | Salt Lake City | UT | 84152 | MI |
| | Max Exploration, LLC | P.O. Box 9287 | Salt Lake City | UT | 84109 | MI |
| | HK Oil & Gas, LLC | P.O. Box 95285 | South Jordan | UT | 84095 | MI |
| | CLH - Minerals, LLC | P.O. Box 3759 | Manhattan Beach | CA | 90266 | MI |
| | SunTrust Mortgage, Inc. | 901 Semmens Avenue | Richmond | VA | 23224 | MTG |
| | Clear Creek Resource Partners | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| T13N - R63W | The te Velde Family LLLP | 7619 Road 19 | Fort Lupton | CO | 80621 | SI |
| Sec. 28: All | Audie Hoke and Cherie R. Hoke | 2509 Crosstimbers Drive | College Station | TX | 77840 | MI |
| | Bold Resources, LLC | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | MAP2009-OK c/o MAP Royalty, Inc. | 101 North Robinson Avenue, Suite 1000 | Oklahoma City | OK | 73102 | MI |
| | Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 | MI |
| | Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 | MI |
| | Charles W. and Patty N. Brown, LLC | 6408 Outabounds Court | Oklahoma City | OK | 73116 | MI |
| | Kyle D Shutt, as Trustee of the Kianna Royalty Trust, a Revocable Trust dated 3/1/19933 | P.O. Box 20571 | Oklahoma City | OK | 73156 | MI |
| | The J. Christopher Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | The Michael L. Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Kaiser-Francis Mid-Continent Limited Partnership | P.O. Box 2280 | Tulsa | OK | 74101 | WI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 | WI |
| | Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 | WI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Enerquest Oil & Gas, L.L.C. | 12368 Market Drive | Oklahoma City | OK | 73114 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | WI |
| | Renegade Resources, LLC c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Simmons Bank | 3001 Brighton Boulevard, Suite 718 | Denver | CO | 80216 | MTG |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Farmers & Merchants Bank of Colby | P.O. Box 797 | Colby | KS | 67701 | MTG |
| T13N - R63W | Joseph and Allison Ward | 535 Road 143 | Carpenter | WY | 82054 | SI |
| Sec. 29: All | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Production Credit Association of the Midlands | P.O. Box J | Torrington | WY | 82240 | MTG |
| | First State Bank, Division of Glacier Bank, Torrington Branch | P.O. Box 1098 | Torrington | WY | 82240 | MTG |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| T13N - R63W<br>Sec. 30: E2E2 | Leonarda Oberwise, Trustee under the | 484 Road 143 | Carpenter | WY | 82054 | SI / MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | The Mountain States Telephone and Telegraph Company | 931 14th Street | Denver | CO | 80202 | ROW |
| T13N - R63W<br>Sec. 30: W2E2 | Michael L. Oberwise | 3656 Red Baron Drive | Colorado Springs | CO | 80911 | SI / MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Norwest Bank Colorado, NA | 1740 Broadway | Denver | CO | 80274 | MTG |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T13N - R63W<br>Sec. 30: Lots 1, 2, E2NW | Marion O. Reeder, Trustee of the | 4100 Road 205 | Carpenter | WY | 82054 | SI |
| | Grayrock Minerals, LLC | 5950 Cedar Springs Road, Suite | Dallas | TX | 75235 | MI |
| | WYOCO Royalty Partners, LLC, a | 410 17th Street, Suite 1150 | Denver | CO | 80202 | MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Cheyenne Light, Fuel and Power | 1301 W. 24th Street | Cheyenne | WY | 82001 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| T13N - R63W<br>Sec. 30: Lots 3, 4, E2SW | WOV, LLC | P.O. Box 460868 | Denver | CO | 80246 | WI |
| | WYDJ Energy LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | WI / ORRI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | WI / ORRI |
| | Faith Partners Land Company, LLC | 4772 Tara Ct. | West Bloomfield | MI | 48323 | WI / ORRI |
| | LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 | ORRI |
| | WYDJ Investments I LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | ORRI |
| | WYDJ ORI Investments I, LLC | P.O. Box 460868 | Denver | CO | 80246 | ORRI |
| | Diana K. Acheson and Fred L Acheson, Co-Trustees of he Fred L. Acheson and Diana K. Acheson Joint Revocable Trust U/A dated 10-16-2015 | P.O. Box 220 | Hillsdale | WY | 82060 | SI / MI |
| | Jill Jahn, aka Jill Tower aka Jill F. | P.O. Box 156 | Fishtail | MT | 59222 | MI |
| | Keith Tower | 10360 Ski Hill Road | Leavenworth | WA | 98826 | MI |
| | ETC Land LLC | P.O. Box 1770 | Red Lodge | MT | 59068 | MI |
| | Cox Minerals LLC | P.O. Box 2015 | Billings | MT | 59103 | MI |
| | Janice Ann Taylor aka Jan Taylor aka Janice A. Taylor | 636 E. Magnesium Rd. Apt C-111 | Spokane | WA | 99208 | MI |
| | Ross M. Taylor | 34752 Bachelor Flat Road | St. Helens | OR | 97051 | MI |
| | Kimberly T. Dunn | 2631 W. Dell Drive | Spokane | WA | 99208 | MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | Laramie Operating LLC, a Colorado limited liability company | 1120 Lincoln Street, Suite 1605 | Denver | CO | 80203 | ROW |
| | U S West Communications, Inc. | 6101 Yellowstone Road | Cheyenne | WY | 82009 | ROW |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| T13N - R63W<br>Sec. 31: E2 | The Gordon Malm Revocable Trust | P.O. Box 55 | Albin | WY | 82050 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 | MTG |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Pine Chalet Properties, LLC | 4022 E. 9th Street | Cheyenne | WY | 82001 | ROW |
| T13N - R63W<br>Sec. 31: Lots 1, 2, 3, 4, E2W2 | Pine Chalet Properties, LLC | 4022 E. 9th Street | Cheyenne | WY | 82001 | SI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | U.S. Bank Trust Company, N.A. | 950 17th Street | Denver | CO | 80202 | MTG |
| | Wells Fargo Bank , N.A. | 150 East 42nd St., 40th Floor | New York | NY | 10017 | MTG |
| | Wells Fargo Bank West | 1740 Broadway | Denver | CO | 80274 | MTG |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Tallgrass Colorado Pipeline, Inc. | 370 Van Gordon Street | Lakewood | CO | 80228 | ROW |
| | The Gordon Malm Revocable Trust dated 02-20-1998 | P.O. Box 55 | Albin | WY | 82050 | ROW |
| T13N - R63W<br>Sec. 32: All | Pine Chalet Properties, LLC | 4022 E. 9th Street | Cheyenne | WY | 82001 | SI |
| | Gordon Malm Revocable Trust | P.O. Box 55 | Albin | WY | 82050 | SI |
| | Westco Family Limited Partnership | P.O. Box 1888 | Gilmer | TX | 75644 | MI |
| | Fanny L. Malm, Trustee of the Gordon Malm Revocable Trust dated | 6360 State Highway 216 | Albin | WY | 82050 | MI |
| | Henry Earl and Margaret D. Montgomery | 4022 E. 9th Street | Cheyenne | WY | 820041 | MI |
| | Malm Ranch Company | 6360 State Highway 216 | Albin | WY | 82050 | MI |
| | Red Harlan Royalties, LTD. | P.O. Box 670766 | Dallas | TX | 75367 | MI |
| | Water Oaks Capital Minerals, LLC | 2101 Cedar Springs, Suite 1600 | Dallas | TX | 75201 | MI |
| | Rearden Minerals, LLC | 5914 W. Courtyard Drive | Austin | TX | 78730 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | Tri-State Generation & Transmission Association, Inc. | 1100 W. 116th Avenue | Westminster | CO | 80234 | ROW |
| | Basin Electric Power Cooperative | 1717 E. Interstate Avenue | Bismarck | ND | 58503 | ROW |
| | Clear Creek Resource Partners | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | U.S. Bank Trust Company, N.A. | 425 Walnut Street, 6th Floor | Cincinnati | OH | 45202 | MTG |
| | Wells Fargo Bank , N.A. | P.O. Box 11701 | Newark | NJ | 07101- | MTG |
| T13N - R63W<br>Sec. 33: All | The te Velde Family LLLP | 7619 Road 19 | Fort Lupton | CO | 80621 | SI |
| | Gordon Malm Revocable Trust | P.O. Box 55 | Albin | WY | 82050 | SI / MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Anadarko Land Corp., a Nebraska corporation, formerly Union Pacific Land Resources Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |
| | J. Christopher Dykes, as Trustee of The J. Christopher Dykes Revocable Trust, dated 10/10/2012 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Robert P. Dykes, as Trustee of The Robert P. Dykes Revocable Trust, dated 10/14/2011 | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | FTC, LLC | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Aspen Leaf, LLC | P.O. Box 1488 | Mustang | OK | 73064 | MI |
| | Fossil Creek Land Company | P.O. Box 485 | Mustang | OK | 73064 | MI |
| | Lemon Creek Oil & Gas, Ltd | P.O. Box 192199 | Dallas | TX | 72519 | MI |
| | Audie Hoke and Cherie R. Hoke | 2509 Crosstimbers Drive | College Station | TX | 77840 | MI |
| | The Ridge, LLC | 392 County Road 145 | Carpenter | WY | 82054 | MI |
| | Bold Resources, LLC | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | Family Tree Corporation | P.O. Box 260498 | Lakewood | CO | 80226 | MI |
| | Deborah L. Shepardson | 811 Heather Lane | Montrose | CO | 81401 | MI |
| | Charles W. and Patty N. Brown, LLC | 6408 Outabounds Court | Oklahoma City | OK | 73116 | MI |
| | MAP2009-OK c/o MAP Royalty, Inc. | 101 North Robinson Avenue, Suite 1000 | Oklahoma City | OK | 73102 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Kaiser-Francis Mid-Continent Limited Partnership | P.O. Box 2280 | Tulsa | OK | 74101 | WI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | WI |
| | McElvain Energy Fund 2010, LLC | 1050 17th Street, Suite 2500 | Denver | CO | 80265 | WI |
| | Macquaire Oil and Gas Holdings, Inc. | 333 Clay Street, Suite 4200 | Houston | TX | 77002 | WI |
| | EOG Resources, Inc. | P.O. Box 4362 | Houston | TX | 77210 | WI |
| | Enerquest Oil & Gas, L.L.C. | 12368 Market Drive | Oklahoma City | OK | 73114 | WI |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | WI |
| | Crow Creek Resources, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | WI |
| | Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | WI |
| | Shoreline Energy Holdings II, Inc. | 600, 209 8th Avenue SW | Calgary | AB | T2P 1B8 | WI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Renegade Resources, LLC c/o Palisade Energy, LLC | 1200 17th Street, Floor 27 | Denver | CO | 80202 | ORRI |
| | GBK Corporation | P.O. Box 21468 | Tulsa | OK | 74121 | ORRI |
| | Outlaw Exploration, LLC | 8033 Coventry Drive | Castle Rock | CO | 80108 | ORRI |
| | Chris E. Hansen | 1059 Buffalo Ridge Road | Castle Pines | CO | 80108 | ORRI |
| | Renegade Exploration, LLC | 890 E. Nichols Avenue | Centennial | CO | 80122 | ORRI |
| | NexGen Royalty Holdings, LLC | 5251 DTC Parkway, Suite 800 | Greenwood Village | CO | 80111 | ORRI |
| | RT Communications, Inc | P.O. Box 506 | Worland | WY | 82401 | ROW |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| | Clear Creek Resource Partners Holdings LLC | 717 17th Street, Suite 1525 | Denver | CO | 80202 | ROW |
| | Simmons Bank | 3001 Brighton Boulevard, Suite 718 | Denver | CO | 80216 | MTG |
| | UMB Bank N.A. | 1670 Broadway, 5th Floor | Denver | CO | 80202 | MTG |
| | ANB Bank | 3033 East 1st Avenue | Denver | CO | 80206 | MTG |
| | Farmers & Merchants Bank of Colby | P.O. Box 797 | Colby | KS | 67701 | MTG |
| | Farm Service Agency | 1560 B-Johnston Street | Wheatland | WY | 82201 | MTG |
| | American AgCredit, FLCA | 45065 W. 29th Street | Greeley | CO | 80634-8763 | MTG |
| T13N - R63W<br>Sec. 34: All | Robert M. Roof, Jr. and Sheala Roof | 390 Road 146 | Carpenter | WY | 82054 | SI / MI |
| | Farmer Family Trust | 5135 Syracuse Road | Cheyenne | WY | 82009 | SI |
| | John L. and Janet I. Farmer | 5135 Syracuse Road | Cheyenne | WY | 82009 | SI / MI |
| | Linda D. and Stephen G. Nelson | 5200 N.E. 69th Terrace | Kansas City | MO | 64119 | MI |
| | Francis Edward Oline Intervivos Trust, dated 11/5/2003 | 1522 Copperville Road | Cheyenne | WY | 82001 | MI |
| | Donald A. and Stacy L. Edgar | 17892 Bagby Road | Green Ridge | MO | 65332 | MI |
| | James E. Edgar aka James Eugene Edgar | 1906 Euclid | Wichita | KS | 67213 | MI |
| | Charles J. and Caroline J. Edgar | 1225 SE 260th Road | Clinton | MO | 64735 | MI |
| | Ruth Enfield Edgar | Unknown Address | | | | MI |
| | Alice E. and Gary W. Jones | 4512 Pool Road | Joplin | MO | 64801 | MI |
| | Roseshell A. Ward | Unknown Address | | | | MI |
| | Cassandra J. Ward | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Charlotte L. Sharp | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Manuel Blanco, IIII | Unknown Address | | | | MI |
| | WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Ruth M. and John P. Rome | 6516 Hedge Lane Terrace, Apt. # 106 | Shawnee | KS | 66226 | MI |
| | Elah and Margaret B. Helper | 6009 East Boise Street | Mesa | AZ | 85205 | MI |
| | Lincoln Energy Partners, LLC | P.O. Box 6975 | Denver | CO | 80206 | MI |
| | Platte Valley Energy, LLC | 852 Broadway, Suite 300 | Denver | CO | 80203 | MI |
| | AK Resources, LLC | P.O. Box 6975 | Denver | CO | 80206 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | High West Energy, a Cooperative | 6270 County Road 212 | Pine Bluffs | WY | 82082 | ROW |
| | Outrigger DJ Operating LLC | 1200 17th Street, Suite 900 | Denver | CO | 80202 | ROW |
| T13N - R63W<br>Sec. 35: All | Robert M. Roof, Jr. and Sheala Roof | 390 Road 146 | Carpenter | WY | 82054 | SI |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | SI / ROW |
| | ONEOK Bakken Pipeline, LLC | P.O. Box 871 | Tulsa | OK | 74102 | SI / ROW |
| | Crow Creek Cattle, LLC | 7678 Road 17 | Fort Lupton | CO | 80621 | SI |
| | Robert M. Roof, Jr. and Sheala Roof | 390 Road 146 | Carpenter | WY | 82054 | SI / MI |
| | Roy F. and Barbara J. Young | 4820 Road 214 | Burns | WY | 82053 | SI / MI |
| | Elah and Margaret B. Helper | 6009 East Boise Street | Mesa | AZ | 85205 | MI |
| | Platte River Energy, LLC | 852 Broadway, Suite 300 | Denver | CO | 80203 | MI |
| | WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Linda D. and Stephen G. Nelson | 5200 N.E. 69th Terrace | Kansas City | MO | 64119 | MI |
| | Alice E. and Gary W. Jones | 4512 Pool Road | Joplin | MO | 64801 | MI |
| | Roseshell A. Ward | Unknown Address | | | | MI |
| | Cassandra J. Ward | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Charlotte L. Sharp | 21833 Hisle Road | Martin | SD | 57551 | MI |
| | Manuel Blanco, IIII | Unknown Address | | | | MI |
| | Occidental Petroleum Corporation | 5 Greenway Plaza, Suite 110 | Houston | TX | 77046 | MI |
| | Charles J. and Caroline J. Edgar | 1225 SE 260th Road | Clinton | MO | 64735 | MI |
| | Donald A. and Stacy L. Edgar | 17892 Bagby Road | Green Ridge | MO | 65332 | MI |
| | James E. Edgar aka James Eugene Edgar | 1906 Euclid | Wichita | KS | 67213 | MI |
| | Loyd Farms, GP, James A. and Lonna J. Loyd | 66732 WCR 136 & 87 | Hereford | CO | 80732 | MI |
| | Ellen Crowley, Attorney In Fact for Leota Russel aka Leota M. Russell | P.O. Box 287 | Cheyenne | WY | 82003 | MI |
| | Abraham Black, Trustee of the Black Family Trust, 10/13/1997 | Unknown Address | | | | MI |
| | Deborah A. Campbell aka Debra A. Campbell | P.O. Box 596 | Martin | SD | 57551 | MI |
| | Alice E. and Gary W. Jones | 4512 Pool Road | Joplin | MO | 64801 | MI |
| | Ruth M. and John P. Rome | 6516 Hedge Lane Terrace, Apt. # 106 | Shawnee | KS | 66226 | MI |
| | Thomas W. Stagg | 1309 Ironwood Street | Boulder City | NV | 89004 | MI |
| | Mark R. Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | David F. Stagg | 9609 239th Street North | Port Byron | IL | 61275 | MI |
| | Elenor Stagg King | P.O. Box 3033 | Clinton | IA | 52732 | MI |
| | AK Resources, LLC | P.O. Box 6975 | Denver | CO | 80206 | MI |
| | Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 | MI |
| | James David and Kathleen Edna Young | Unknown Address | | | | MI |
| | Lincoln Energy Partners, LLC | P.O. Box 6975 | Denver | CO | 80206 | MI |
| | Anadarko Land Corp., a Nebraska corporation, formerly Union Pacific Land Resources Corporation | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Denver | CO | 80202 | MI |
| | Ruth Enfield Edgar | Unknown Address | | | | MI |
| | Cowboy Land, LLC | 141 Union Boulevard, Suite 310 | Lakewood | CO | 80228 | MI |

| Description | Organization | Address 1 | City | Region | Postal Code | TYPE OF INTEREST |
|---|---|---|---|---|---|---|
| | Gene G. Purdy | Unknown Address | | | | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | Colorado Liberty Pipeline, LLC | 2331 City West Boulevard | Houston | TX | 77042 | ROW |
| T13N-R63W<br>Sec. 36: All | Ronald D. and D Anna L. Catterson | 384 Road 148 | Carpenter | WY | 82054 | SI |
| | Everett Rhodes | P.O. Box 447 | Carpenter | WY | 82054 | SI |
| | Cody L. Smith | 291 Road 152 | Carpenter | WY | 82054 | SI |
| | Jason W. Smith and Lisa J. Smith | P.O. Box 401 | Carpenter | WY | 82054 | SI / MI |
| | Ryan F. and Vicki M. Nelson | 2070 Franklin Street | Laramie | WY | 82070 | SI / MI |
| | Dale R. and Sharon Martin | 324 County Road 148 | Carpenter | WY | 82054 | MI |
| | Lucy Ann Stagg | 3205 Highsky Drive | Midland | TX | 79707 | MI |
| | Mark R. Stagg | 22218 North Lake Village Drive | Katy | TX | 77450 | MI |
| | David V. Bowman Olds and Darla G. Olds | 6615 West Rowland Avenue | Littleton | CO | 80128 | MI |
| | Edith E. Lang, Trustee, or her successors in trust, of the Edith E. Lang Living Trust, dated 4/5/1999 | P.O. Box 37, Route 1 | Carpenter | WY | 82054 | MI |
| | Gary P. and Norma Jean Smith | P.O. Box 365 | Carpenter | WY | 82054 | MI |
| | Randy J. Peters | Unknown Address | | | | MI |
| | Joseph G. Lynch | P.O. Box 4308 | Williston | ND | 58802 | MI |
| | Eric Wilt | P.O. Box 1473 | Williston | ND | 58802 | MI |
| | Dale A. Swanson | 339 Indian Paintbrush Drive | Golden | CO | 80401 | MI |
| | David G. Majewski | 11823 South Maxwell Hill Road | Littleton | CO | 80127 | MI |
| | Dennis W. Yockim | 8765 Greensborough Place | Littleton | CO | 80129 | MI |
| | Cody L. Smith | 291 Road 152 | Carpenter | WY | 82054 | MI |
| | Loyd Farms, GP, James A. and Lonna J. Loyd | 66732 WCR 136 & 87 | Hereford | CO | 80732 | MI |
| | OKSA Minerals, LP | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Fredericksburg Royalty, Ltd | 5111 Broadway | San Antonio | TX | 78209 | MI |
| | Curzon Management, LLC | 408 Canterbury Hill | San Antonio | TX | 78209 | MI |
| | BCP Energy, LLC | P.O. Box 472059 | Fort Worth | TX | 76147 | MI |
| | Wake Energy, LLC | P.O. Box 5074 | Edmond | OK | 73083 | MI |
| | Swanson Production Company | 339 Indian Paintbrush Drive | Golden | CO | 80401 | MI |
| | Lynx Oil Company | 9736 West Swarthmore Drive | Littleton | CO | 80123 | MI |
| | Peteco Properties, LLC | 5236 Pinehurst Drive | Boulder | CO | 80301 | MI |
| | Hydrocarbon Minerals II, LLC | P.O. Box 2157 | Bridgeview | IL | 60455 | MI |
| | Oneonta Resources, LLC | 5228 Lonetree Drive | Loveland | CO | 80537 | MI |
| | Arrow Energy, LLC | 809 W. 3rd Street | McCook | NE | 69001 | MI |
| | LOR Capital I, LLC | P.O. Box 460868 | Denver | CO | 80246 | MI |
| | WYDJ Royalty Holdings LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Valeen Energy, LLC | 4733 South Elizabeth Court | Cherry Hills Village | CO | 80113 | MI |
| | Tallgrass High Plains Carbon Storage, LLC | 370 Van Gordon Street | Lakewood | CO | 80228 | WI |
| | OneOK Elk Creek Pipeline, L.L.C. | 100 West 5th Street | Tulsa | OK | 74103 | ROW |

**ATTACHMENT A-3: Wyoming Oil and Gas Conservation Commission, Wyoming Office of State Lands and Investment, and Bureau of Land Management Correspondence**

W.S. 35-11-313(ii)(N): Proof of notice to surface owners, mineral claimants, mineral owners, lessees and other owners of record of subsurface interests as to the contents of such notice. Notice requirements shall at a minimum require:
(I) The publishing of notice of the application in a newspaper of general circulation in each county of the proposed operation at weekly intervals for four (4) consecutive weeks;
(II) A copy of the notice shall also be mailed to all surface owners, mineral claimants, mineral owners, lessees and other owners of record of subsurface interests which are located within one (1) mile of the proposed boundary of the geologic sequestration site.

This Attachment is specific to Wyoming Oil and Gas Conservation Commission, Wyoming Office of State Lands and Investment, and Bureau of Land Management.

- WDEQ Correspondence to WOGCC, BLM, and OSLI – December 11, 2023
- Correspondence from BLM – January 9, 2024
- Correspondence from WOGCC – January 11, 2024
- Consider Application for Special Use Lease, OSLI – June 1, 2023

January 2, 2024

Mr. Duane W. Spencer
Wyoming Deputy State Director Minerals and Lands
Bureau of Land Management
5353 Yellowstone Road
Cheyenne, WY 82009

***Sent via email: dspencer@blm.gov***

Mr. Tom Kropatsch
Supervisor
Wyoming Oil and Gas Conservation Commission
2211 King Boulevard
Casper, WY 82604

***Sent via email: tom.kropatsch@wyo.gov***

Mr. Tyler Seno
Commercial Leasing Manager
Trust Land Management Division
Wyoming Office of State Lands & Investments
122 West 25th Street, Suite W103
Cheyenne, WY 82002

***Sent via email: tyler.seno@wyo.gov***

RE: Tallgrass High Plains Carbon Storage, LLC, Eastern Wyoming Sequestration Hub, Spirea I-1
UIC Class VI Application 2023-041, Facility ID No. WYS-021-00155
Surface/Mineral Ownership and Leases, Laramie County

Dear Messrs. Spencer, Kropatsch and Seno:

Tallgrass High Plains Carbon Storage, LLC (Tallgrass) has recently submitted an Underground Injection Control (UIC) Class VI permit application to the Wyoming Department of Environmental Quality (WDEQ) to construct and operate a UIC Class VI injection well in Laramie County, Wyoming. UIC Class VI wells are used to inject carbon dioxide ($CO_2$) into deep rock formations. Class VI requirements are designed to protect underground drinking water sources and address: siting, construction, operation, testing, monitoring, and closure.

The Eastern Wyoming Sequestration Hub, Spirea I-1 well is proposed and has not yet been drilled. WDEQ is providing the following information, as applicable, for your review:

- **Operator**: Tallgrass High Plains Carbon Storage, LLC.
- **Well Name**: Spirea I-1
- **Proposed Well location**: 41.052367, -104.424469
- **Legal Location**: SW ¼ NW ¼ of Section 34, Township 13 North, Range 63 West of the 6th Principal Meridian.
- **Area of Review**: See Figure 3.23: Map of the AOR and a 1-mile Boundary (attached).
- **Injection formation**: Permian-aged sand package; the Lyons formation, bounded by the upper confining layers – the Chugwater and Goose Egg formations, and the lower confining layer, the Satanka formation.

- **Depth of injection**: 9,447 to 9,511 feet below ground surface
- **Well Status**: Proposed
- **Permit Status**: The application is under completeness and technical adequacy review at the current time. Dependent on WDEQ's completeness review and Tallgrass' responsiveness to WDEQ's comments and request for additional information, if identified, the draft permit and other pertinent documents are anticipated for public notice in late-2024. A public hearing will be scheduled during the public notice period. A copy of the permit application is available on the WDEQ website at: https://deq.wyoming.gov/water-quality/groundwater/uic/class-vi/ under "Class VI Applications."
- **Owner of oil and gas lease w/in Area of Review**: Tallgrass High Plains Carbon Storage, LLC. is a privately held company that proposes to lease the privately held surface within the Area of Review. The location of the proposed Class VI well and the AoR is privately held both under surface ownership and minerals.
- **Surface ownership w/in Area of Review**: See attachment: Appendix K Notification List (attached).
- **Mineral ownership w/in Area of Review**: See attachment: Appendix K Notification List (attached).

WDEQ is requesting verification of the information identified above along with the following:

1. Is any part of the project located on State or Federal Lands? This includes the proposed well location, surface structure placement, access roads to the well site, and $CO_2$ plume in the subsurface.
2. If yes to question number 1 above, has the UIC Class VI applicant contacted your office and applied for applicable permits through your agency?
3. Are there wells (active, shut in, or plugged and abandoned) that your agency has permitted within the area of review of the proposed project? If yes, WDEQ requests a list of those wells and any information, such as well completion logs or plugging and abandonment logs, that may be available.

Please provide any comments that the Wyoming Oil and Gas Conservation Commission, Wyoming Office of State Lands and Investments, and Bureau of Land Management may have on the proposed injection well within 30 days of receipt of this letter.

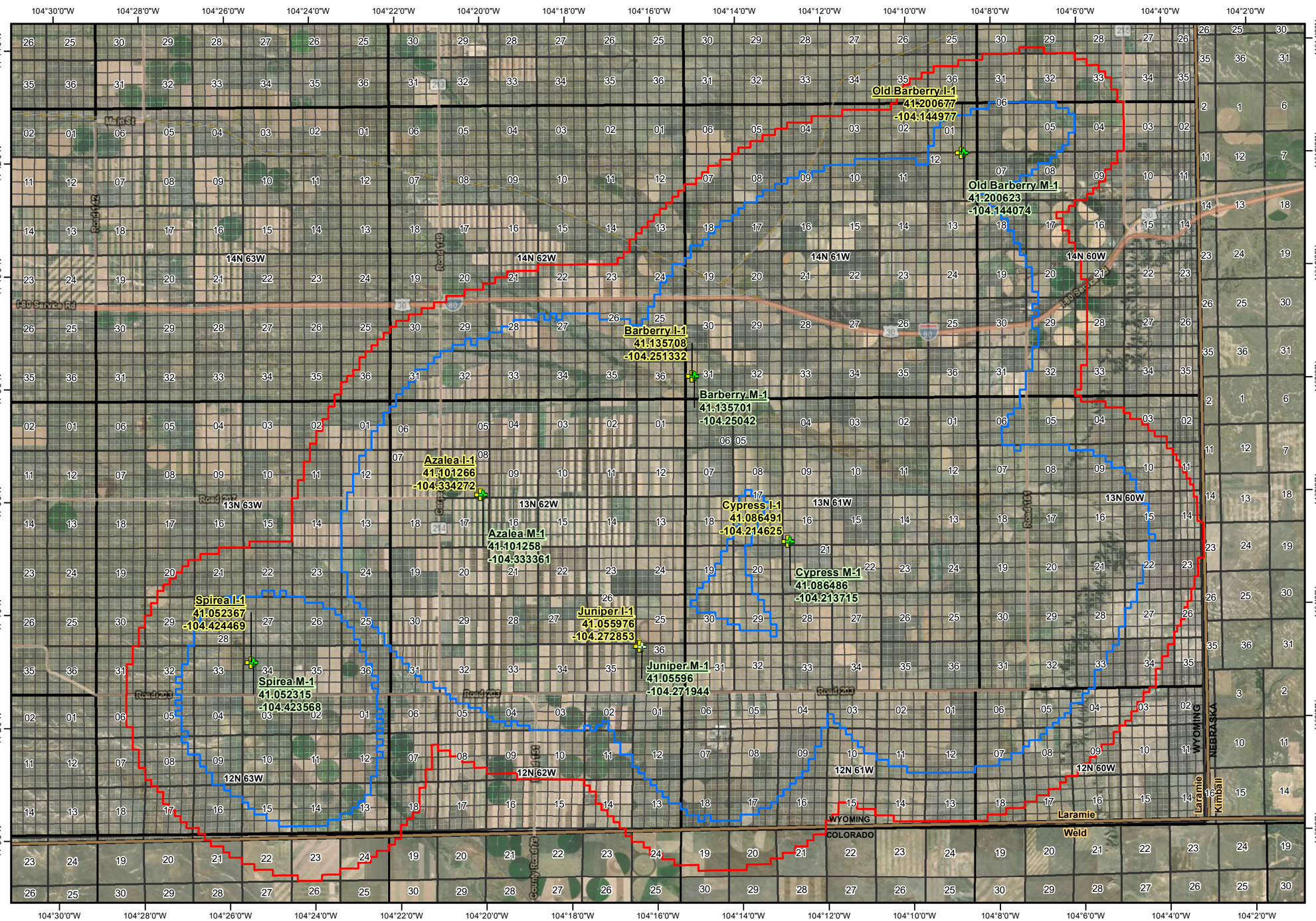
Sincerely,

Graeme Finley

Graeme Finley, P.G.
Senior Project Geologist
Wyoming Department of Environmental Quality
Water Quality Division

Attachments: Figure 3.23: Map of AOR Plus a 1-Mile Boundary; Appendix K: Notification List

cc: Lily Barkau, P.G., Tyler Harris, P.G., WDEQ/WQD




AoR Plus 1 Mile Radius

AoR - End of Monitoring

**Project Wells**

- Proposed Injection Well
- Proposed Monitoring Well
- Monitoring Well

PLSS Sections

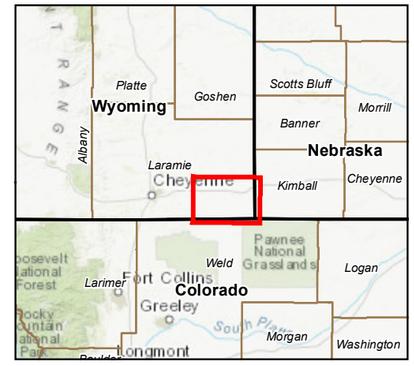
PLSS Second Division: Q-Q

PLSS Third Division: Q-Q-Q

PLSS Townships

US State Boundary

Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community




# Final AoR Map

## Tallgrass High Plains Carbon Storage, LLC Laramie County, WY

Produced by:
Numeric Solutions LLC
Geoinformation Management
1536 Eastman Avenue, Suite D
Ventura, CA 93103
805-794-5011 | www.numericsolutions.com

Author: DJR

Date: 11/14/2023

Document Name: 3.24_Final_AOR_Map

Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
Projection: Transverse Mercator
Datum: North American 1983

N

0 2 4 8 Miles

0 6,000 12,000 24,000 Feet

1:130,000

Lily Barkau <lily.barkau@wyo.gov>

# Re: Trailblazer High Plains Carbon Storage, LLC Eastern Wyoming Sequestration Hub

1 message

**Tyler Seno** <tyler.seno@wyo.gov> Tue, May 30, 2023 at 9:02 AM
To: Lily Barkau <lily.barkau@wyo.gov>

1. Yes a portion of this project will involve state lands:

Township 12 North, Range 60 West, 6th P. M.
Section 08: N2
Section 16: All, less 4.87 acres

Township 12 North, Range 61 West, 6th P. M.
Section 16: All

Township 13 North, Range 60 West, 6th P. M.
Section 6: All
Section 16: All
Section 30: SE

Township 13 North, Range 61 West, 6th P. M.
Section 36: All

Township 13 North, Range 62 West, 6th P. M.
Section 16: N2, NESW, SE

Township 13 North, Range 63 West, 6th P. M.
Section 16: All

Township 14 North, Range 61 West, 6th P. M.
Section 4: Lots 3, 4

Township 14 North, Range 62 West, 6th P. M.
Section 16: All
Section 28: N2, N2S2 Section 36: All

Township 15 North, Range 61 West, 6th P. M.
Section 2: SW
Section 16: All

Township 15 North, Range 62 West, 6th P. M.
Section 36: All

2. Tallgrass High Plains Carbon Storage, LLC has applied for a special use lease for the purpose of CO2 storage in subsurface pore space. The application is being presented to the board of land commissioners for consideration on June 1, 2023.

3. OSLI is not the ultimate permitting agency for wells, solely the use of the surface and/or subsurface.

Tyler Seno
Commercial Leasing Manager
Trust Land Management Division

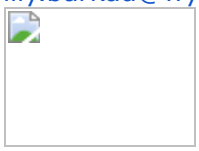
Wyoming Office of State Lands & Investments
122 West 25th Street, Suite W103
Cheyenne, WY 82002
Office: 307.777.5762

On Fri, May 26, 2023 at 3:01 PM Tyler Seno <tyler.seno@wyo.gov> wrote:

> Will do, thanks!
>
> Tyler Seno
> Commercial Leasing Manager
> Trust Land Management Division
> Wyoming Office of State Lands & Investments
> 122 West 25th Street, Suite W103
> Cheyenne, WY 82002
> Office: 307.777.5762
>
> On Fri, May 26, 2023 at 2:57 PM Lily Barkau <lily.barkau@wyo.gov> wrote:
>
> > Yes, please. Making sure you are kept in the loop in case they haven't been in contact with work in the SE corner of the state.
> >
> > Lily R. Barkau, P.G.
> > Groundwater Section Manager
> > Water Quality Division
> > 200 W. 17th St. 2nd Floor, Cheyenne, WY 82002
> > Phone: 307-777-7072 | Fax: 307-635-1784
> > lily.barkau@wyo.gov
> >
> > **NOTE:** WDEQ/WQD is going paperless! Please submit documents electronically to the WDEQ/WQD Groundwater Section through this link: **https://bit.ly/WDEQ-WQD**
> >
> > If you need a large file upload link for documents greater than 30 MB, please email **deq-ims-wqd@wyo.gov**
> >
> > On Fri, May 26, 2023 at 2:53 PM Tyler Seno <tyler.seno@wyo.gov> wrote:
> >
> > > Good afternoon!
> > >
> > > I am sorry this got buried deep in the inbox. Is this still information you are looking for? If so I can get it completed early next week.
> > >
> > > Tyler Seno
> > > Commercial Leasing Manager
> > > Trust Land Management Division
> > > Wyoming Office of State Lands & Investments
> > > 122 West 25th Street, Suite W103
> > > Cheyenne, WY 82002
> > > Office: 307.777.5762
> > >
> > > On Fri, May 5, 2023 at 2:50 PM Lily Barkau <lily.barkau@wyo.gov> wrote:
> > >
> > > > All,
> > > >
> > > > Attached is WDEQ's notification letter requesting surface/mineral ownership and lease information regarding the above-referenced project. If you have any questions, please do not hesitate to contact me at my contact information below or Laurel Morrow at 307-777-7608 or laurel.morrow@wyo.gov.

Sincerely,
Lily

Lily R. Barkau, P.G.
Groundwater Section Manager
Water Quality Division
200 W. 17th St. 2nd Floor, Cheyenne, WY 82002
Phone: 307-777-7072 | Fax: 307-635-1784
lily.barkau@wyo.gov



**NOTE:** WDEQ/WQD is going paperless! Please submit documents electronically to the WDEQ/WQD Groundwater Section through this link: **https://bit.ly/WDEQ-WQD**

If you need a large file upload link for documents greater than 30 MB, please email **deq-ims-wqd@wyo.gov**

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Wyoming State Office
5353 Yellowstone Road
Cheyenne, WY 82009
www.blm.gov/WY

In Reply Refer To:
**2800 (WY925)**
**WYWY105862215**

JAN 0 9 2024

Wyoming Department of Environmental Quality
Water Quality Division
Attn: Ms. Lily Barkau
200 West 17th Street
Cheyenne, WY 82002

Ms. Barkau,

Thank you for providing the Bureau of Land Management (BLM) with an opportunity to submit comments on Tallgrass High Plains Storage, LLC's (Tallgrass's) Class VI Underground Injection Control (UIC) Class VI applications submitted to the Wyoming Department of Environmental Quality (WDEQ) – Water Quality Division (WQD) for the Azalea I-1 (Application 2023-264), the Barberry I-1 (Application 2023-039), the Cypress I-1 (Application 2023-040), the Old Barberry I-1 (Application 2023-263), and the Spirea I-1 (Application 2023-041).

In your letters of December 11, 12, and 18, 2023, and of January 2, 2024, you asked the following questions, to which our answers are provided below:

1. ***Is any part of the project located on State or Federal Lands? This includes the proposed well location, surface structure placement, access roads to the well site, and CO2 plume in the subsurface.***

   **BLM Response:** There are 480.00 acres (listed under question number 2, below) of BLM-administered public lands located within the maximum plume extent east-southeast of the proposed Cypress I-1. The application does not include a description of the access roads to reach the injection wellsite, so we cannot address whether access roads will cross BLM-administered public lands. However, it appears unlikely that any proposed roads for this project would cross BLM-administered public lands.

2. ***If yes to question number 1 above, has the UIC Class VI applicant contacted your office and applied for applicable permits through your agency?***

   **BLM Response:** Tallgrass High Plains Carbon Storage LLC has submitted a pore space right-of-way (ROW) application to the BLM for the use of BLM-administered federal pore space. The ROW application (BLM serial number WYWY105862215) includes 480.00 acres

of BLM-administered public lands located in T. 12 N., R. 60 W., sec. 4, SW1/4; and T. 13 N., R. 60 W., sec. 28, W1/2 (Sixth P. M.). The WDEQ-WQD has agreed to be a cooperating agency for the BLM's National Environmental Policy Act compliance document. The BLM completed public scoping on December 15, 2023, and is currently preparing the environmental assessment.

3. ***Are there wells (active, shut in, or plugged and abandoned) that your agency has permitted within the area of review of the proposed project? If yes, WDEQ requests a list of those wells and any information, such as well completion logs or plugging and abandonment logs, that may be available.***

   **BLM Response:** No.

Thank you for providing the BLM an opportunity to submit comments on this pending application. If you have any further questions, please feel free to contact Duane Spencer, Deputy State Director, Minerals and Lands by phone at 307-775-6146 or by email at dspencer@blm.gov

Sincerely,

DUANE SPENCER

Digitally signed by DUANE SPENCER
Date: 2024.01.09 15:02:32 -07'00'

Duane Spencer
Deputy State Director,
Minerals and Lands
BLM Wyoming State Office

cc: Mr. Tom Kropatsch (tom.kropatsch@wyo.gov)
Supervisor
Wyoming Oil and Gas Conservation Commission
2211 King Boulevard
Casper, WY 82604

Mr. Timothy Novotny (tnovotny@blm.gov)
Field Manager
BLM – Rawlins Field Office
1300 N. Third Street
Rawlins, WY 82301-2407

Travis Bargsten (WY925)
Dave Chase (WY924)
Bill Beck (WY921)

Governor Mark Gordon, Chairman | Tom Kropatsch, State Oil & Gas Supervisor
Commissioners Jenifer Scoggin | Erin Campbell | Jimmy E. Goolsby | Ken Hendricks

January 11, 2024

Ms. Lily Barkau
Wyoming Department of Environmental Quality
Water Quality Division
200 West 17th Street
Cheyenne, WY 82002

RE: Tallgrass High Plains Storage LLC Applications for Class VI Underground Injection Control Permits for Azalea I-1, Barberry I-1, Cypress I-1, Old Barberry I-1, and Spirea I-1

Dear Ms. Barkau,

The Wyoming Oil and Gas Conservation Commission (WOGCC) respectfully submits the following comments in response to your notice of Tallgrass High Plains Storage, LLC (Tallgrass) Class VI applications for the referenced wells.

The WOGCC has permitted wells that are in the area of review (AOR) of the proposed Tallgrass injection wells. The WOGCC has reviewed the list of wells that Tallgrass included in the injection well applications submitted to the Wyoming Department of Environmental Quality (WDEQ) and agrees with Tallgrass that these are the list of wells permitted by the WOGCC in the AOR. Therefore, another list of these same wells is not included in this comment letter.

All information related to these wells that may be in the WOGCC records is public information available on the WOGCC website and/or in the paper files at the WOGCC office. Tallgrass should review these records to ensure full knowledge of current status and condition of each well and to ensure none of these wells will create any issues with the project proposed by Tallgrass. WOGCC staff are available to assist Tallgrass with this task and with evaluation of each of these wellbores.

Thank you for the opportunity to provide these comments, please contact me if you have any questions or need any additional information.

Sincerely,

Tom Kropatsch
State Oil and Gas Supervisor

cc: Mr. Duane Spencer (dspencer@blm.gov)

## ATTACHMENT A-4: WDEQ Completeness Review and Permittee Response to Comments

The Permittee must comply with these conditions and adhere to these plans as they are approved by the Administrator by their incorporation into this permit.

- WDEQ comments dated February 1, 2024
- Tallgrass High Plains Carbon Storage LLC Response to Comments dated May 9, 2024
- WDEQ comments dated June 27, 2024
- Tallgrass High Plains Carbon Storage LLC Response to comments dated July 5, 2024
- Tallgrass High Plains Carbon Storage LLC Supplemental Information dated July 11, 2024
- Tallgrass High Plains Carbon Storage LLC Supplemental Information dated July 13, 2024
- Tallgrass High Plains Carbon Storage LLC Supplemental Information dated July 15, 2024
- Tallgrass High Plains Carbon Storage LLC Supplemental Information dated July 17, 2024
- Tallgrass High Plains Carbon Storage LLC Supplemental Information dated July 18, 2024
- WDEQ Final Application Checklist dated July 13, 2024

February 12, 2024

Tallgrass High Plains Carbon Storage, LLC
Attn: Mr. Kyle Quackenbush
4200 West 115th Street
Leawood, KS 66211

*Sent Via Email: kyle.quackenbush@tallgrass.com*

RE: Tallgrass High Plains Carbon Storage, LLC, Eastern Wyoming Sequestration Hub, Spirea I-1
UIC Class VI Application 2023-041, Facility ID No.: WYS-021-00155
Laramie County, Wyoming

Dear Mr. Quackenbush,

The Wyoming Department of Environmental Quality, Water Quality Division (WDEQ/WQD) has reviewed the Underground Injection Control (UIC) Program Class VI Permit Application 2023-041 for the Eastern Wyoming Sequestration Hub, Spirea I-1 Class VI well, submitted by Tallgrass High Plains Carbon Storage, LLC (Tallgrass) on December 21, 2023. Based on WDEQ's review, the application has been deemed incomplete at this time. The attached comments are provided to aid Tallgrass in submitting all the information necessary to complete the application.

Comments identified in the attached documents must be addressed within six months or the permit may be denied and the incomplete application will be returned. If Tallgrass wishes to expedite the review and response to comments process, WDEQ/WQD encourages Tallgrass to review the attached comments and contact the UIC Program to discuss the comments prior to submitting a response to comments or a revised application. If you have questions or would like to schedule a meeting to discuss the comments, please contact me at (307) 473-3478 or graeme.finley@wyo.gov.

Sincerely,

Graeme Finley

Graeme Finley, P.G.
Senior Program Geologist
Underground Injection Control Program – Class VI
Wyoming Department of Environmental Quality

Attachments: 2024-0212_UIC_2023-041_Tallgrass-Spirea-well_app-cmnt
2024-0212_UIC_2023-041_Tallgrass-Spirea-well_review-checklist

cc: Lily Barkau, P.G., Tyler Harris, P.G., - WDEQ/WQD
Katy Larson, UIC Program Coordinator, Tallgrass High Plains Carbon Storage, LLC (katy.larson@tallgrass.com)

**PERMIT APPLICATION COMPLETENESS REVIEW**
**UNDERGROUND INJECTION CONTROL PROGRAM**
*WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY*
*WATER QUALITY DIVISION*

| | |
|---|---|
| PROJECT: | Eastern Wyoming Sequestration Hub – Spirea I-1 |
| LOCATION: | Laramie County, WY |
| APPLICANT: | Tallgrass High Plains Carbon Solutions, LLC. |
| OWNER: | Kyle Quackenbush |
| TITLE: | Segment President and Vice President – Liquids (Crude Oil and $CO_2$) |

X APPLICATION X PLANS X SPECS X PROPOSAL X REPORT

| | |
|---|---|
| DATE ON REPORT: | December 21, 2023 |
| DATE RECEIVED BY WDEQ: | December 21, 2023 |
| WDEQ REVIEWER: | Graeme Finley P.G., Senior Project Geologist, WQD |
| DATE OF THIS REVIEW: | February 12, 2024 |
| **ACTION:** | **Application Incomplete, Comments Attached** |

GENERAL COMMENTS

1. The basis for the following comments is identified below as part of the Application Completeness/Preliminary Technical Adequacy Review. A checklist for the application is attached for further reference.

2. Applicants have a maximum of six (6) months to address WDEQ's comments. If the requested information is not addressed within the six (6) month period, the permit will be denied and the incomplete application shall be returned.

3. Resubmittal of information for a deficient application will start the sixty (60) day review period again.

4. Please ensure consistent units are used throughout the application. For example, SSTVD is reported in some situations while MD is used in others. While SSTVD is acceptable, please also report the corresponding MD.

5. Please ensure to use a consistent operator name throughout the application.

SPECIFIC COMMENTS

1. In accordance with Wyoming Water Quality Rules (WWQR), Chapter 24, Section 10 (b)(iv), please provide a completed Permit Application Form 1, Section 1, General Information, specifying the Facility Location Address. A proposed PLSS location and latitude and longitude may be used in the absence of an actual street address.

2. In accordance with WWQR, Chapter 24, Section 10(b)(vi)(ix), please provide maps of the following or a statement that such entities do not exist within the AoR:

    a. All state or EPA-approved cleanup sites
    b. All surface bodies of water
    c. Other pertinent surface features, including structures intended for human occupancy;

3. In accordance with WWQR, Chapter 24, Section 10(b)(xi)(E), please provide the following geomechanical data:

    a. Stress
    b. Rock Strength
    c. In situ fluid pressures

    If this geomechanical data has not yet been collected, please provide a full, stepwise procedure for how this data will be collected for WDEQ review and approval.

4. In accordance with WWQR, Chapter 24, Section 10(b)(xix), please provide procedures for the formation testing programs to be done in the Spirea I-1 and M-1.

5. In accordance with WWQR, Chapter 24, Section 10(b)(xx), a detailed stimulation plan will need to be submitted for WDEQ's review and approval prior to issuance of authorization to inject under a modified permit. If the stimulation is to be done under the Permit to Construct as part of formation testing, this plan needs to be submitted with a response to these comments for WDEQ's review and approval prior to issuance of the Permit to Construct.

6. In accordance with WWQR, Chapter 24, Section 13(c)(i-iv), please provide a discussion of how Tallgrass will re-evaluate wells for corrective action within an adjusted AoR.

    a. Section 3.5 *Area or Review and Corrective Action Plan* of the permit application states that there are 654 wells (57 oil wells) within the AoR. The Barberry I-1 permit application (Permit # 2023-039) reports 657 wells (60 oil wells) within the AoR. Please address this discrepancy and adjust Table 3.4 and Table B.6 of Appendix B accordingly.

7. In accordance with WWQR, Chapter 24, Section 10(b)(xxxiii), the well plugging plan requires the type, grade, and quantity of material to be used in well plugging to be submitted. Additionally, please provide information on how these materials meet or exceed the American Petroleum Institute standards per WWQR Chapter 24, Section 14(b)(i).

8. In accordance with WWQR, Chapter 24, Section 24(a)(ii)(K), the predicted rate of $CO_2$ plume migration within the injection zone is required. Please update the permit application to include this information.

9. In accordance with WWQR, Chapter 24, Section 24(a)(ii)(M), the predicted rate of $CO_2$ trapping is required. Please update the permit application to include this information.

10. In accordance with WWQR, Chapter 24, Section 26(a)(ii), financial assurance for each phase of the project is required including monitoring and testing; financial assurance for each phase is required to be reported separately from other financial assurance estimates.

11. In accordance with WWQR, Chapter 24, Section 10(b)(xxxi), a public liability insurance certificate that, in addition to meeting the requirements of W.S. § 35-11-313(f)(ii)(O), demonstrates that the public liability insurance policy meets the requirements of Section 26(l)(i)(B) of this Chapter; identifies each facility by name, address, and EPA Identification Number; and identifies the amounts and types of coverage for each facility is required prior issuance of a Permit to Construct.

12. Section 2.4.1.5 of the permit application states "Note oil saturation > 0 is indicative of oil-based mud invasion." Provide evidence as to how oil saturation in the core taken in the Juniper M-1 can be as high as 46% due to drilling with oil-based mud.

13. Section 3.1.2 *Supporting Maps* of the permit application states "As discussed in Appendix B, the extent of the pressure front at the critical pressure threshold is smaller than the $CO_2$ plume extent, therefore the AoR is determined by the $CO_2$ plume extent."

    a. Please clarify how you arrived at this conclusion incorporating evaluations of the AoR (using the EPA approach) that indicate a different methodology (i.e. the risk-based approach) is appropriate.

14. Section 3.6 *Reevaluation of AoR and Corrective Action Plan* of the permit application states "A report will be generated to include the data and results demonstrating that no changes are necessary. If material changes have occurred, then the conceptual model will be updated with the new data and a report will be generated and sent to WYDEQ. This report will include comparisons between the previous simulation and the updated version, details of potential corrective action and a current status of the corrective action. The report will be submitted to WDEQ within one year of the reevaluation."

    a. If any change to the AoR has occurred, the conceptual model must be updated and a report generated which must be submitted with the next scheduled semiannual report. If a report that demonstrates no changes are necessary is submitted, it must also be submitted with the next scheduled semiannual report for WDEQ review and approval. Changes to the AoR and corrective action plan will require a permit modification.

15. Table 4.3 *Actions necessary to determine cause of events and appropriate emergency response* of the permit application states "If a seismic event occurs within the AoR of the injection well, of a magnitude greater than 3.0, review the pressure and volume injection history to determine if there is a correlation with the injection activities. Confirm that the well has maintained mechanical integrity and whether a loss of $CO_2$ containment has occurred."

    a. The WDEQ requires quarterly reporting of all seismic events greater than 1.0. At this time, the WDEQ cannot support a minimum magnitude reporting threshold of 3.0. Final minimum magnitude reporting threshold numbers cannot be established until further data is collected from the well area.

16. Section 4.4.2 *Proposed Monitoring Well Casing and Cementing Programs* of the permit application states "The well will be drilled through the Sundance and will penetrate the top of the Chugwater," whereas Section 4.5.2.1 *Pre-plugging Procedures 2. Determination of bottomhole reservoir pressure* states "The well is not expected to be perforated or open to

any formation and the total depth at drilling and completion was to be above the containment layers for the Lyons sequestration reservoir."

a. These statements both refer to the monitoring wells and contradict each other. Please clarify if the Chugwater or Goose Egg will be penetrated by the monitoring well(s).
b. Monitor wells cannot penetrate the upper confining zone as drilling operations may compromise the integrity of the confining zone.

17. Section 4.6.3 *Groundwater and Soil Gas Monitoring* of the permit application states "High Plains does not plan to monitor soil gas at this time as monitoring efforts in the first permeable layer above the confining zone and shallow groundwater sampling will identify leaks before a soil gas survey would."

    a. Pursuant to WWQR Chapter 24 Section 20(b)(ix), soil gas monitoring is required. Please provide a soil gas monitoring plan.

18. Section 2.3.6 *Fluid Samples* of the permit application states "Based on the narrative of the well operations prior to and during sampling, it is not reasonable or possible to claim that water samples obtained are truly from and representative of the Lyons Formation." Section 2.3.6 (PDF page 69) goes on to state "A review of the daily drilling and completion reports shows there is a possibility that the Lyons Formation water sample collected could be contaminated from brine present in the wellbore at the time of sampling. High Plains will collect additional fluid samples in the Lyons Formation in the Spirea I-1 prior to injection."

    a. Tallgrass will also need to collect water samples from the Sundance Formation, Hygiene Sandstone Member of the Pierre Shale, and the following shallow USDWs:

        i. Quaternary alluvial and terrace deposits
        ii. "High Plains Regional Aquifer System" or "Tertiary Aquifer System"
        iii. Ogallala, Arikaree, and White River formations
        iv. Lance and Fox Hills formations

19. Per Specific Comment 18, Tallgrass shall submit their water sampling plan(s) to the WDEQ for review and approval prior to collecting any samples, to ensure such samples will be satisfactory to the WDEQ.

20. Tallgrass shall submit final plans for water sampling, monitoring, completions, injection and monitor well plugging, internal and external mechanical integrity testing, and any other well operation procedures to the WDEQ for review and approval prior to performing any of these activities.

**END OF COMMENTS**

**WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY**
**WATER QUALITY DIVISION, UNDERGROUND INJECTION CONTROL PROGRAM**
**CARBON SEQUESTRATION, CLASS VI**
**Spirea I-1**
**2023-041**
**WYS-021-00155**

| √ | REQUIRED ITEM | LOCATION IN APPLICATION | COMMENT |
|---|---|---|---|
| **GENERAL INFORMATION** | | | |
| X | Application Type (Conversion, Modification, New) | Page 1, #1 | New |
| X | A brief description of the nature of the business and the activities to be conducted that require the applicant to obtain a permit under this Chapter; (Chapter 24, Section 10(b)(i)) | Page 4, #2 | "The proposed Eastern Wyoming Sequestration Hub (EWS Hub) will be located in the southeastern corner of Wyoming, in Laramie County, Section 34, Township 13N, Range 63W. Additional documentation will be provided as available."<br>Later sections of the application detail the exact location and amount of $CO_2$ to be injected. |
| X | The name, address, and telephone number of the operator, and the operator's ownership status and status as a federal, state, private, public, or other entity; (Chapter 24, Section 10(b)(ii)) | Page 3, #1 | All contact information provided.<br>Limited Liability Corporation, privately owned company. |
| X | Up to four Standard Industrial Classification codes that best reflect the principal products or services provided by the facility;<br>(Chapter 24, Section 10(b)(iii)) | Page 4, #3 | 4953 – Refuse systems (Nonhazardous water disposal sites)<br>4619 – Pipelines, not elsewhere classified |
| - | The name, address, and telephone number of the facility; (Chapter 24, Section 10(b)(iv)) | Page 3, #1, | Not provided. In the absence of a physical address, please provide latitude and longitudinal coordinates and PLSS description. |
| X | Whether the facility is located on Indian lands. (Chapter 24, Section 10(b)(v)) | Page 4, #5<br>Table 3.3 (p. 135) | Not located on Indian lands. |
| X | The location of the geologic sequestration project is identified by section, township, range, and county, noting which sections (if any) include Indian lands; (Chapter 24, Section 10(b)(v)) | Table 1.1 (p. 35)<br>Figure 1.1 (p. 35) | Spirea I-1 Location:<br>SWNW Section 34 T13N R63W, Laramie Co., 41.052367° - 104.424469°<br>Figure 1.1 Shows the entire project area. No part of the project area is on Indian lands. |
| X | Within the area of review, a listing and status of all permits or construction approvals associated with the geologic sequestration project received or applied for under any of the following programs or corresponding state programs: RCRA, UIC, NPDES, PSD, Nonattainment program under CAA, National Emissions Standards for Hazardous Air Pollutants pre-construction approval under CAA, Dredge and fill permitting program under CWA, other relevant environmental permits, including State permits (Chapter 24, Section 10(b)(vi)(A-G)) | Table 3.1 (p. 133)<br>Table 3.2 (p. 134) | No other environmental permits are currently associated with this permit.<br>Other permits that are deemed necessary as the project progresses, will be acquired. (Table 3.2). |
| X | Within the area of review, a list of other relevant permits associated with the geologic sequestration project that the applicant is required to obtain; (Chapter 24, Section 10(b)(vii)) | Table 3.1 (p. 133)<br>Table 3.2 (p. 134) | Other permits that are deemed necessary as the project progresses, will be acquired. (Table 3.2).<br>5 other Class VI wells are associated with the project – 2023-235 (Juniper), 2023-040 (Cypress), 2023-264 (Azalea), 2023-263 (Old Barberry), 2023-039 (Barberry), including one to four monitoring wells associated with each permit (one deep, upper confining unit MW and up to 3 shallow aquifer MW). |
| X | A statement of whether the geologic sequestration project is within a state-approved water quality management plan area, a state-approved wellhead protection area or a state-approved source water protection area; (Chapter 24, Section 10(b)(viii)) | Page 4, #4<br>Figure 3.6 (p. 138) | |
| X | Pursuant to Wyoming Water Quality Rules (WWQR), Chapter 8, Section 6(c)(ii), the discharge of waste will not degrade or decrease the availability of mineral resources, including oil and gas. Therefore, prior to submitting an application to construct a UIC Class VI injection well, the WDEQ strongly encourages applicants to collaborate with nearby leases and mineral ownership owners to demonstrate that the proposed injection activities will present no damage to existing or future recovery of sub-surface minerals. Any permit challenge that is upheld by the WOGCC is grounds for the WDEQ to deny the issuance of the Class VI UIC permit. | Section 2.2.2.1 (pp. 63-64) | There is no known hydrocarbon production from formations below the Muddy J, approximately 1,175' above the Lyons within the project area. |

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| - | A map showing the injection well(s) for which a permit is sought and the applicable area of review, consistent with Section 13 of this Chapter;<br>• Within the area of review, the map shall list the number, or name and location of:<br>• All injection wells, producing wells, abandoned wells, plugged wells, dry holes, or deep stratigraphic boreholes;<br>• All state- or EPA-approved subsurface cleanup sites;<br>• All water quality management plan areas, wellhead protection areas, and source water protection areas;<br>• All surface bodies of water, springs, mines (surface and subsurface), quarries, and water wells;<br>• Other pertinent surface features, including structures intended for human occupancy;<br>• Roads; and<br>• State and Indian reservation boundaries;<br>(Chapter 24, Section 10(b)(vi)(ix)) | Figure 1.1 (p. 35)<br>Figure 3.4 (p. 136)<br>Figure 3.5 (p. 137)<br>Figure 3.6 (p. 138)<br>Table 3.4 (pp. 139-142) | Springs and water wells shown on Figure 3.4.<br>All injection, producing, plugged, abandoned, dry holes displayed on Figure 3.5.<br>Source water and wellhead protection areas shown on Figure 3.6<br>Table 3.4 lists all oil and gas wells in the AoR.<br>State boundary is shown on all map figures. No Indian lands are present in the AoR.<br><br>Surface bodies of water and human occupied structures are not denoted on maps. Roads are present on satellite imagery but need to be highlighted |
| X | Wyoming Conservation Executive Orders 2019-3 (Sage Grouse) and 2020-1 (Migration Corridor) | Page 2, Sections a and b | No portion of the project falls within SGCAs or Migration Corridors. |
| X | Published notice of the application in a newspaper of general circulation in each county of the proposed operation is required. Published for four consecutive weeks and copy of the notice mailed to all surface owners, mineral claimants, mineral owners, lessees, and other owners of record of subsurface interest that are located within one mile of the proposed boundary of the geologic sequestration site. (W.S. 35-11-313(f)(ii)(N)) | | Affidavit of publishing received. |
| X | A list of contacts for states or Tribes on Indian lands or territories (Chapter 24, Section 10(b)(xxxvi)) | Page 5, #6; Page 4, #5 | No part of the project on Indian lands. |
| X | Sections of permit applications that represent engineering work shall be sealed, signed, and dated by a licensed professional engineer as required by W.S. § 33-29-601. (Chapter 24, Section 10(e)) | Page 10 | Stamped by Ray Clanton, PE #17641. |
| X | Sections of permit applications that represent geologic work shall be sealed, signed, and dated by a licensed professional geologist as required by W.S. § 33-41-115. (Chapter 24, Section 10(f)) | Page 9 | Stamped by Eric White, PG #4303. |
| X | All applications for permits, reports, or information submitted to the Administrator shall be signed by a responsible corporate officer. (Chapter 24, Section 10(c)) | Page 6, #9 | Signed by Kyle Quackenbush, Segment President and VP – Liquids (Crude Oil and $CO_2$), Tallgrass. |
| X | The application shall contain the following certification by the responsible corporate officer signing the application:<br><br>"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations." (Chapter 24, Section 10(d)) | Page 6, #9 | Signed by Kyle Quackenbush, Segment President and VP – Liquids (Crude Oil and $CO_2$), Tallgrass. |
| **GEOLOGIC NARRATIVE/SITE CHARACTERIZATION INFORMATION** | | | |
| *The permit application will likely include a narrative description of the geologic structures, injection and confining zones, and fluid and solid geochemistry to meet the requirements of Chapter 24. The geologic narrative may be supported by maps, cross sections, and tabular data.* | | | |
| | **Regional Geologic Structure and Hydrogeologic Properties**<br>*The description of the geologic structure and hydrogeologic properties of the proposed storage site and overlying formations must include the items below:* | | |
| - | **Maps and Cross Sections of the AoR** | Appendix B | CMG GEM model: "The data sources used to construct the static geocellular model include well logs, 2D seismic data, and elements drawn from available literature." |

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| | *The maps and cross sections may be accompanied by a brief narrative description interpreting the figures and providing an overview of key features important to the project.*<br>• Meets the requirements of Section 13 of this Chapter;<br>• Is based upon modeling;<br>• Uses all available data, including data available from any logging and testing of wells within and adjacent to (within one (1) mile of) the area of review; and<br>• Describes the area of review by township, range, and section to the nearest ten (10) acres, as described under the general land survey system;<br>*(Chapter 24, Section 10(b)(x))* | Sections 3.1.1-3.1.2 (pp. 128-132)<br>Section 3.4 (p. 158) | Multiple figures have the AOR displayed.<br><br>Applicant proceeded to use the EERC's risk-based AoR approach but did not offer the results of modelling (i.e. EPA approach) that would have indicated that approach was appropriate. |
| - | **Demonstration of Site Suitability**<br>*This narrative demonstration may be accompanied by maps, cross sections, tables or relevant geological data, or descriptions of model inputs/results. It must describe:*<br>• The suitability of the injection zone (An injection zone of sufficient areal extent, thickness, porosity, and permeability to receive the total anticipated volume of the carbon dioxide stream (Chapter 24, Section 12 (a)(i)), and<br>• The suitability of the confining zone (Confining zones that are free of transmissive faults or fractures and of sufficient areal extent and integrity to contain the injected carbon dioxide stream and displaced formation fluids and allow injection at proposed maximum pressures and volumes without initiating or propagating fractures in the confining zones or causing non-transmissive faults to become transmissive. *(Chapter 24, Section 12(a)(ii))*<br>*(*) It may also describe additional confining zone(s); a description of additional confining zones is not required of all projects.*<br>• Isopach maps of the proposed injection and confining zones, a structural contour map aligned with the top of the proposed injection zone, and at least two (2) geologic cross-sections of the area of review reasonably perpendicular to each other and showing the geologic formations from the surface to total depth; *(Chapter 24, Section 10(b)(xi)(A))* | Section 1.6 (p. 37)<br>Located throughout Section 2 (pp. 39-127) | Section 1.6 details the criteria used to determine site suitability.<br>Geologic narrative, Cross sections, Structure and Isopach maps for UCZ, Injection Zone and LCZ provided.<br><br>All depths associated with the UCZ, Injection Zone and LCZ are reported in SSTVD with no well elevation reported. Please provide measured depth values for all depths reported in the permit application.<br><br>Upper Confining: Chugwater, MD, Goose Egg, MD<br>Injection Zone: Lyons, MD<br>Lower Confining: Satanka, MD |
| X | **Information on Faults and Fractures**<br>*This may be a narrative description of the location, orientation, and properties of known or suspected faults and fractures and a discussion supporting a determination that they would not interfere with containment. It may be accompanied by maps and cross sections and be supported by analyses of core samples, the results of geophysical surveys, pore pressure data, etc.*<br>• Location, orientation, and properties of known or suspected faults and fractures that may transect the confining zones in the area of review and a determination that they will not allow fluid movement;<br>• Information on seismic history that has affected the proposed area of review including knowledge of previous seismic events and history of these events, the presence and depth of seismic sources, and a determination that the seismicity will not allow fluid movement out of the injection zone;<br>*(Chapter 24, Section 10(b)(xi)(B))* | Figure 2.17 (p. 74)<br>Section 2.4.3 (pp.118-120) | Figure 2.17 shows the 2D seismic lines used to determine there are no faults in the AoR.<br><br>2.4.3.1 states "The upper confining zone if free of transmissive faults or fractures within the AoR."<br><br>2.4.3.1 also mentions Tallgrass ran SLB oil-based ultrasonic borehole image tool and interpreted open fractures to be drilling induced. Dipole sonic was used to look for open fractures further from the wellbore. There is no discussion of the interpretation of the diploe sonic. |
| X | **Data on the Injection Zone(s)**<br>*This narrative may describe plans to collect or the results of geologic cores, outcrop data, seismic surveys, well logs, lithologic descriptions, and other field data used to characterize the injection zone(s), including geology/facies changes. The application must address the following types of data on the injection zone(s):* | Throughout Section 2.4 (pp. 75-124) | Data from the Juniper M-1 strat test:<br>Table 2.22 (p. 99) Lyons: Depth: 9,128'-9,194'; Avg. 67' thick; Sandstone, predominantly quartz with <2% clay and no calcite.<br>Table 2.7 (p. 80) Porosity: 15.7% (core); Perm: 501 mD (core) |

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| | • Data sufficient to demonstrate the effectiveness of the injection and confining zones, including:<br>o Data on the depth, areal extent, thickness, mineralogy, porosity, vertical permeability, and capillary pressure of the injection and confining zones within the area of review; and<br>o A description of geologic changes based on field data that may include geologic cores, outcrop data, seismic surveys, well logs, and names and lithologic descriptions;<br>*(Chapter 24, Section 10(b)(xi)(D))* | | Section 2.4 focuses on the geological characteristics of the injection zone. Data presented includes core and log data as well as mineralogy. Preliminary geomechanical information indicates a fracture gradient of 0.57 psi/ft and will be updated with future data. Data presented includes core analysis, XRD data, water sampling, cross sections and maps of the Lyons, well logs (Juniper M-1 and others). |
| X | **Data on the Confining Zone(s)**<br>*This narrative may describe plans to collect or the results of geologic cores, outcrop data, seismic surveys, well logs, lithologic descriptions, and other field data used to characterize the confining zone(s), including geology/facies changes. The application must address the following types of data on the confining zone(s):*<br>• Data sufficient to demonstrate the effectiveness of the injection and confining zones, including:<br>o Data on the depth, areal extent, thickness, mineralogy, porosity, vertical permeability, and capillary pressure of the injection and confining zones within the area of review; and<br>o A description of geologic changes based on field data that may include geologic cores, outcrop data, seismic surveys, well logs, and names and lithologic descriptions;<br>*(Chapter 24, Section 10(b)(xi)(D))* | Section 2.4.2 including all subsections (pp. 99-118) | Section 2.4.2 including all subsections covers the geology of the UCZ and LCZ. Core, log and geochemical data are provided, as are maps and cross sections. The permeability of the UCZ and LCZ are in the 0.001mD range with 5% avg phi, indicating good sealing rocks are present. The UCZ and LCZ are both predominantly shale and are sufficiently thick (Satanka 189', Chugwater/Goose Egg ~500'). |
| | **Geomechanical and Petrophysical Information about the Confining Zone(s)**<br>*A narrative description of the confining zone(s) may describe the testing performed (or planned) and available results in a tabular and/or graphical form; it may include maps and present seismic or other geophysical data, core data, or well logs. The application must address the following about the confining zone(s): (Chapter 24, Section 10(b)(xi)(E))* | Section 2.4.2.1.3 (p. 109)<br>Table 2.25 (p. 110)<br>Section 2.4.2.2.3 (pp. 118-120)<br>Section 2.4.2.2.4 (p. 117)<br>Table 2.28 (p. 117) | Elastic properties available for UCZ and LCZ (some properties pending analysis) are present. |
| X | Fractures. | Section 2.4.3.1 (pp. 116-119) | The upper confining zone is free of transmissive faults or fractures within the AoR. |
| - | Stress. | Table 2.25 (p. 110)<br>Table 2.28 (p. 117) | TBD |
| X | Ductility. | Table 2.25 (p. 110)<br>Table 2.28 (p. 117) | Young's modulus for Goose Egg 25.6-55.1.<br>Young's modulus for Satanka 34.6-35.2. |
| - | Rock strength. | Table 2.25 (p. 110)<br>Table 2.28 (p. 117) | TBD |
| - | In situ fluid pressures. | | Missing |
| X | **Information on Seismic History**<br>*A narrative description of the presence and depth of seismic sources and a determination that seismicity would not interfere with containment that may be accompanied by tables and/or maps of seismic events, sources, and depths. (Chapter 24, Section 10(b)(xi)(C))* | Section 2.4.3.2 (p. 121-124) | "The probabilistic acceleration map, shown in Figure 2.42, illustrates that the EWS Hub is located in one of the lowest-risk areas of Wyoming." |
| X | **Geologic and Topographic Maps and Cross Sections**<br>*These maps and cross sections of regional geology, hydrogeology, and local geologic structure may be accompanied by a narrative description or interpretations of logs or core data. (Chapter 24, Section 10(b)(xi)(F))* | Throughout Sections 2 & 3 | Myriad maps and cross sections included in Sections 2 & 3. |
| | **Hydrologic Information/Maps and Cross Sections of USDWs** | | |

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| | *The maps and stratigraphic cross sections of the vertical and lateral limits of all USDWs may be accompanied by a narrative interpretation of the figures. The maps/cross sections must show: (Chapter 24, Section 10(b)(xiv))* | | |
| X | Water wells and springs within the AoR. | Figure 3.4 (p. 136) | Embedded map is small scale and difficult to read, however, Tallgrass included a standalone high resolution image in the Figures and Tables folder. |
| X | Their positions relative to the injection zone(s). | Figure 2.2 (p, 41)<br>Figure 2.7 (p. 47)<br>Figure 2.8 (p. 48) | Shown in stratigraphic column; Figure 2.2<br>Shown on cross section; Figure 2.7, Figure 2.8 |
| X | The direction of water movement, where known. | Section 2.2.2 (p. 61)<br>Figure 2.14 (p. 63)<br>Figure 2.20 (p. 78) | Groundwater recharges in the mountains on the western flank of the basin and travels eastward. |
| - | **Baseline Geochemical Data**<br>*The narrative description of available geochemical data on fluid- and solid-phase geochemistry of all subsurface formations (including USDWs) in the AoR may describe: results or planned sampling/testing, the parameters analyzed, and any geochemical modeling that was performed, along with data sources, data quality or gaps, and sampling/testing methods. It may be accompanied by tabular or graphical data, statistics, and maps. (Chapter 24, Section 10(b)(xvi))* | Section 4.4.3 #2 (p. 213) | "High Plains has no plans to collect fluid samples from subsequent monitoring wells and will instead collect fluid samples from relevant formations in all injection wells within the EWS Hub."<br>Chapter 24 requires water samples from injection zone and lowermost USDW.<br><br>Only geochemical data for the Lyons is presented. |
| - | **Groundwater Classification**<br>*For the characterization required by W.S. 35-11-313(f)(ii)(B), information necessary for the Division to classify the receiver and any secondarily affected aquifers under Water Quality Rules and Regulations Chapter 8; (Chapter 24, Section 10(b)(xv))* | Section 2.2.1 (pp. 49-58)<br>Section 2.3.6 (pp. 69-71)<br>Appendix C | DEQ has questions on sampling procedure. Permit application also express doubts in water sample quality (Section 2.3.6, pp. 70-71). Will require new sample taken in Spirea I-1 via a sampling methodology approved by WDEQ.<br><br>Lyons TDS ~224,000ppm. |
| **WELL CONSTRUCTION** | | | |
| X | **$CO_2$ Compatibility**<br>*The compatibility of the carbon dioxide stream with fluids in the injection zone and minerals in both the injection and the confining zones, based on the results of the formation testing program, and with the materials used to construct the well; (Chapter 24, Section 10(b)(xviii))* | Section 2.4.1.8 (pp. 95-99)<br>Section 4.3.2 (p. 193) | Section 2.4.1 Covers formation compatibility.<br>Section 4.3.2 states "To meet the requirements of WYDEQ Chapter 24 §20(b)(iii), High Plains will conduct corrosion monitoring of the well's tubing, casing, and pipeline materials using a corrosion coupon monitoring system." Please provide documentation that all well construction materials meet the various API codes listed in Chapter 24 Section 14. |
| - | **Formation Testing Program**<br>*Proposed formation testing program to obtain an analysis of the chemical and physical characteristics of the injection zone and confining zone and that meets the requirements of Section 17 of this Chapter; (Chapter 24, Section 10(b)(xix))* | Section 4.3 (pp.188-192)<br>Table 4.21: I-1 logging program (p.207)<br>Table 4.26: M-1 logging program (p. 212) | Please provide summaries of formation testing done in the Juniper and planned for the Spirea I-1 and M-1.<br>Table 4.21 is the Spirea I-1 proposed logging program.<br>Table 4.26 is the Spirea M-1 proposed logging program. |
| - | **Stimulation Program**<br>*Proposed stimulation program, a description of stimulation fluids to be used, and a determination that stimulation will not allow fluid movement out of the injection zone; (Chapter 24, Section 10(b)(xx))* | Section 5 (pp. 237-240)<br>Appendix J | Section 5 states "A stimulation program will be executed upon WYDEQ approval."<br>Appendix J contains an example of a mud acid workover. It is labelled Proposed Stimulation Plan, but appears incomplete.<br>Proposed plans are acceptable for now, but a detailed workover plan needs to be approved prior to well construction. |
| X | **Schematics**<br>*A wellbore schematic of the subsurface construction details and surface wellhead construction of the injection and monitoring wells; (Chapter 24, Section 10(b)(xxii))* | Figure 4.3 (p. 195)<br>Figure 4.5 (p. 202)<br>Figure 4.6 (p. 209) | Proposed well design for three groundwater monitoring wells.<br>Spirea I-1<br>Spirea M-1 |
| X | **Design and Construction** | Figure 4.3 (p. 196)<br>Table 4.18 (p.205)<br>Table 4.19 (p.205) | Tables and wellbore diagrams provide most of the required information. See note regarding API standards in **Well Construction > $CO_2$ Compatibility** in this checklist. |

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| | *Injection well design and construction procedures that meet the requirements of Section 14 of Chapter 24, including the information listed in Section 14(c)(ii) of Chapter 24; (Chapter 24, Section 10(b)(xxiv))* | Table 4.20 (p. 206) | |
| - | **Logging, Sampling and Testing Prior to Injection Well Operations**<br>*All available logging and testing program data on the wells required by Section 17 (Chapter 24, Section 10(b)(xxvii))* | Section 4.3 (pp.188-201)<br>Table 4.21: I-1 logging program (p.207)<br>Table 4.26: M-1 logging program (p. 212) | Please provide summaries of formation testing done in the Juniper M-1 and planned for the Spirea I-1 and M-1.<br>Table 4.21 is the Spirea I-1 proposed logging program. Logging program looks good.<br>Table 4.26 is the Spirea M-1 proposed logging program. Logging program looks good. |
| **PLANNED WELL OPERATIONS** | | | |
| X | **Proposed Operations**<br>*Proposed procedure that outlines steps to conduct injection operations; (Chapter 24, Section 10(b)(xxi)* | Section 5.0 (pp. 237-240) | Includes SRT procedures. |
| X | **Proposed average and maximum daily rate and volume and/or mass and total anticipated volume and/or mass of the $CO_2$ stream.**<br>*A narrative or tabular description that may be accompanied by calculations. (Chapter 24, Section 10(b)(xvii(A))* | Table 5.1 (p. 237) | 10.62 million metric tons total over 30 years<br>1,656 metric tons/day average<br>4,101 metric tons/day maximum |
| X | **Proposed average and maximum injection pressure.**<br>*A narrative or tabular description that may be accompanied by calculations. (Chapter 24, Section 10(b)(xvii(B))* | Table 5.1 (pg. 237) | 1,597 psi Maximum Surface Injection Pressure<br>1,420 psi Average Surface Operating Injection Pressure<br>1,520 psi Proposed Tubing-Casing Annulus Pressure |
| X | **The source(s) of the $CO_2$.**<br>*A narrative description of the $CO_2$ source. (Chapter 24, Section 10(b)(xvii(C))* | Section 5.0 (pp. 237-238)<br>Table 5.2 (p. 238) | The $CO_2$ to be injected will be sourced from ethanol plants, ammonia plants, and power plants then transported on the Trailblazer pipeline to the Spirea I-1. |
| X | **An analysis of the chemical and physical characteristics of the $CO_2$ stream.**<br>A narrative description that may be accompanied by tables of parameters or analytical reports. *(Chapter 24, Section 10(b)(xvii(D))* | Table 5.2 (p.238) | >95 mol% $CO_2$ |
| X | **Duration**<br>*Anticipated duration of the proposed injection period. (Chapter 24, Section 10(b)(xvii(E))* | Section 5 (p. 237) | 5-30 years depending on injection rate (up to maximum of 10.62 million metric tons total injection) |
| **AREA OF REVIEW (AoR) AND CORRECTIVE ACTION PLAN** | | | |
| | *Proposed area of review and corrective action plan that meets the requirements under Section 13 of Chapter 24 (Chapter 24, Section 10(b)(xxv))* | | |
| - | **The Method for Delineating the AoR.**<br>*A narrative description of the AoR delineation model used, which may include assumptions made, any available outputs/results, and the inputs on which the model is based. It may be accompanied by tables, figures and graphics, or raw data in a tabular format. (Chapter 24, Section 13)* | Section 3.1.1 (p.128) | "The AoR is defined as "the subsurface three-dimensional extent of the carbon dioxide plume, associated pressure front, and displaced fluids, as well as the overlying formations, and surface area above that delineated region" [Ch. 24 §2(c)], the lateral extent of the AoR herein includes any area where the modeled $CO_2$ saturation exceeds 2% at plume stabilization, or where threshold pressure is exceeded in the injection zone at any time during the modeled timeframe."<br><br>The AoR was calculated using the risk-based method, however, the EPA method should have been done first to determine if an alternate method was necessary. Please calculated the AoR using the EPA method and explain why it is or isn't an appropriate method for determining the AoR. |
| X | **AoR Reevaluation Schedule and Criteria, Including:**<br>• *A description of the minimum fixed frequency, not to exceed 5 years, for AoR reevaluations.*<br>• *The monitoring and operational conditions that would warrant a reevaluation of the AoR prior to the next scheduled reevaluation; and*<br>• *How monitoring and operational data will be sued to inform an AoR reevaluation. (Chapter 24, Section 13)* | Section 3.5 (p. 168)<br>Section 3.6 (p. 173) | "High Plains will regularly reevaluate the AoR and corrective action plan, per the requirements of WYDEQ Chapter 24 §13(c), at least every two years during the operational life of the EWS Hub and every five years during the post-injection site care period (until site closure)—or when monitoring and operational conditions warrant a reevaluation prior to the next scheduled reevaluation." |

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| - | **Corrective Action Information**<br>A narrative discussion of how corrective action was/will be conducted. If phased corrective action is planned, the application must describe the following: | Section 3.3 (p. 158)<br>Table 3.10 (p. 168)<br>Section 3.5 (pp. 170-171) | "A total of 654 wells (597 water wells and 57 oil and gas wells) have been identified within the AoR. Of these, only three penetrate the upper confining zone. Two wells are shown in Table 3.10, with Juniper M-1 being discussed separately." This differs from the number of wells within the AoR reported in the Barberry I-1 permit application. Please address this discrepancy.<br><br>Well remediation procedure listed on pp. 170-171. |
| X | How the phasing will be determined. | | No discussion of phasing corrective action. |
| - | How corrective action will be adjusted if there are changes in the AoR. | | No discussion of Corrective Action changes |
| X | How site access for future corrective action will be guaranteed. | Page 5, #7 | Site access is covered on Page 5, #7. |
| | **Tabulation of Wells in the AoR**<br>The AoR and Corrective Action Plan must include a table listing wells within the AoR (within one mile) that penetrate the injection or confining zones or a statement there are no wells that penetrate the confining zone within the AoR. Other penetrations of the confining zone(s), such as underground mines, also must be identified. If a table is submitted, it must include the following information: *(Chapter 24, Section 10(b)(xii-xiii))* | Table 3.4 (pp. 139-142)<br>Table 3.10 (p. 168)<br>Table B.6 (pp. 310-314)<br>Table B.7 (pp. 317-336) | Several tables tabulate wells data for wells within AOR. Table 3.4 is a condensed deep well table and Table B.6 is a more comprehensive table. Table B.7 lists water wells in the AOR, but only has columns for Permit Number, Status, Use, Facility Name and Well Depth. Table 3.10 is a complete table for wells that penetrate the confining zone within the AOR. |
| X | Well Type. | Table 3.10 (p. 168) | Present in table. |
| X | Description of the well's construction. | Table 3.10 (p. 168) | Present in table. |
| X | Date drilled. | Table 3.10 (p. 168) | Present in table. |
| X | Location. | Table 3.10 (p. 168) | Present in table. |
| X | Depth. | Table 3.10 (p. 168) | Present in table. |
| X | Record of plugging and/or completion. | Table 3.10 (p. 168) | WOGCC Completion Reports provided in Appendix A. |
| **TESTING AND MONITORING PLAN** | | | |
| X | **Testing and Monitoring Plan**<br>*Proposed testing and monitoring plan required by Section 20 (Chapter 24, Section 10(b)(xxxii)). The Testing and Monitoring Plan will be a narrative description of planned injection-phase testing activities that is accompanied by maps, tables, illustrations, or step-by-step procedures that describe the following:* | Section 4.3 (pp.188-201) | See below. |
| X | **$CO_2$ Stream Analysis**<br>*Narrative description that may describe analytical parameters, sampling methods, sampling locations, and frequencies.* | Section 4.3.1 (pp. 189-190) | "High Plains will collect continuous samples of the $CO_2$ injection stream and perform analysis to meet the requirements of WYDEQ Chapter 24 §20(b)(i), to obtain data representative of the injectate stream's chemical and physical characteristics."<br>"The $CO_2$ stream samples will be continuously collected from the $CO_2$ pipeline using a gas chromatograph on the flowline before the injection flowmeter." |
| X | **Continuous Recording of Operational Parameters**<br>*Narrative description of devices to continuously monitor and record injection pressure, rate, and volume; tubing-casing annulus pressure; and annulus fluid volume added. May be depicted on well schematics.* | | Various mentions of continuous monitoring through fiber optic cables in wellbore, but no specific discussion of continuous monitoring. |
| X | **Corrosion Monitoring**<br>*Narrative description of corrosion monitoring methods that may describe sampling methods/locations or testing frequency.* | Section 4.3.2 Subsection 2 (p. 193) | "The coupons will be removed quarterly and assessed for corrosion using American Society for Testing and Materials (ASTM) standards at a certified laboratory." |
| X | **Above Confining Zone Monitoring**<br>*Narrative description of planned water quality monitoring that may describe well locations; analytical methods and parameters; sampling locations and methods, formations/depths, and* | Table 4.11 (p. 189) | "Monitoring well with fiber optic and gauges behind casing" |

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| | *frequencies. The description may be accompanied by maps, monitoring well schematics, or tables of analytical parameters and methods.* | | |
| X | **External Mechanical Integrity Testing**<br>*Narrative (sometimes step-by-step) description of mechanical integrity tests (MITs) and their planned frequency. (Chapter 24, Section 10(b)(xxviii))* | Section 4.3.1.1 Subsection 4 (p. 192) | "As required by WYDEQ Chapter 24 §24.19(c) and §24.20(b)(v), a fiber optic (DTS) temperature log will be recorded and archived annually to determine the absence of significant fluid movement, thus ensuring mechanical integrity. Before beginning injection operations, a temperature baseline will be established for future comparisons." |
| X | **Pressure Fall-Off Testing**<br>*Narrative (sometimes step-by-step) description of pressure fall-off tests and their planned frequency.* | Section 4.3.1.1 Subsection 2 (pp. 191-192) | "High Plains will conduct a baseline pressure falloff test before injection and then every five years." |
| X | **Direct $CO_2$ Plume and Pressure Front Tracking**<br>*Narrative description of planned direct methods to track the $CO_2$ plume and pressure front that may include well locations; analytical methods and parameters; sampling locations and formations/depths; and frequencies. The description may be accompanied by maps, monitoring well schematics, or tables of analytical parameters and methods.* | Section 4.3.8 (pg. 196)<br>Table 4.15 (pp. 196-197)<br>Section 4.3.9 (pg. 198) | "Direct and indirect monitoring methods will be used to track the extent of the $CO_2$ plume within the injection formation throughout the injection and post-injection monitoring periods, per the methods described in Table 4.15."<br><br>"The $CO_2$ plume will be directly monitored by temperature and pressure gauges placed via TEC line as well as a fiber optics system behind the casing in both the injection well and the monitoring well." |
| X | **Indirect $CO_2$ Plume and Pressure Front Tracking**<br>*Narrative description of planned indirect methods to track the $CO_2$ plume and pressure front; it may describe: well locations; monitoring equipment; or geophysical survey extent/resolution. The description may be accompanied by maps, monitoring well or equipment schematics, or tables.* | Section 4.3.10 (pg. 198) | "The extent of the $CO_2$ plume will be monitored using time-lapse 2D seismic surveys."<br><br>"High Plains plans to utilize DTS in the Spirea M-1 annually to monitor all zones above the injection zone. Due to the high resolution nature of this tool, this method of monitoring will inform High Plains of any carbon dioxide or saline fluids migrating out of the injection zone." |
| - | ***Surface Air Monitoring and/or Soil Gas Monitoring**<br>*This type of monitoring is not required for all projects; if it is included, it would be a narrative description of planned methods detect $CO_2$ in the soil or atmosphere (including monitoring locations, equipment, and frequencies) that may be accompanied by maps or illustrations.* | Section 4.3.7 (p. 195)<br>Table 4.14 (p.195) | "$CO_2$ in air monitors will also be placed to monitor the air above the water level in each of these monitoring wells." No other air monitoring will be done.<br>"High Plains has determined that a soil gas monitoring plan is not necessary to monitor potential Leakage."<br>Soil Gas Monitoring is required. |
| X | ***Other Monitoring**<br>*Additional monitoring is not required for all projects; if it is included, it would be a narrative description of the types of monitoring (e.g., seismic), including methods, equipment, locations, and frequencies that may be accompanied by maps, illustrations, or tables.* | Table 4.2 (pp. 178-179)<br>Table 4.11 (p. 188) | Seismic monitoring mentioned in Emergency and Remedial Response Plan, Table 4.2.<br>Monitoring program is listed in Table 4.11. |
| X | **Quality Assurance and Surveillance Plan**<br>*Narrative description of planned quality assurance procedures for all testing and monitoring activities.* | Section 4.3.11 (pg. 199)<br>Appendix E | |
| **INJECTION WELL PLUGGING PLAN** | | | |
| X | *Proposed injection and monitoring wells plugging plan required by Section 23 (Chapter 24, Section 10(b)(xxxiii))* | Section 4.5 (p. 214-219) | "This section provides an overview of plugging operations after injection operations have ceased at Spirea I-1. High Plains intends to properly plug and abandon the injection well under the requirements of WYDEQ Chapter 24 §23." |
| X | **Well Plugging Plan**<br>*The Well Plugging Plan may be a narrative (sometimes step-by-step) description of plugging procedures for the injection well. It may be accompanied by schematics and tables. The plan must include the following information:* | Section 4.5 (p. 214-224)<br>Figure 4.7 (p. 219)<br>Figure 4.8 (p. 224) | Figure 4.7 – P&A Wellbore Diagram for Injector<br>Figure 4.8 – P&A Wellbore Diagram for MW |
| X | Tests or measures for determining bottomhole reservoir pressure. | Section 4.5 Pre-plugging procedures #2 (p. 214) | "Bottomhole pressure will be measured with a wireline gauge run through tubing. The well should be shut in for a sufficient time to ensure the reservoir pressures are stabilized." |
| X | External mechanical integrity testing methods. | Section 4.5 Pre-plugging procedures #3 (pp. 214-215) | "External mechanical integrity will be demonstrated through approved temperature logging methods. The following procedure is to demonstrate mechanical integrity, release packer, recover tubing, and clean out the wellbore." |

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| X | The type and number of plugs to be used. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Table 4.27 summarizes plugs, Section 4.5.1 describes the plugs, and Figure 4.7 is the wellbore diagram for the Spirea I-1. |
| X | The placement of each plug, including the elevation of the top and bottom of each plug. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Figure 4.7 |
| X | The type, grade, and quantity of material to be used in plugging. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Table 4.27 and Figure 4.7. |
| X | The method of placement of the plugs. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Narrative in Section 4.5.1 (pp.214-217) |
| **POST-INJECTION SITE CARE (PISC) AND SITE CLOSURE PLAN** | | | |
| | **PISC and Site Closure Plan**<br>*Proposed post-injection site care and site closure plan required by Section 24(a)(Chapter 24, Section 10(b)(xxxiv)). The plan will be a narrative discussion, accompanied by maps, cross sections, tables, or model outputs that must include the following information:* | Section 4.6 (pg. 225-236) | |
| X | The differential between pre-injection and predicted post-injection pressures in the injection zone(s). | Section 4.6.1 (pg. 225-233) | "The maximum injection pressure buildup is 1,391 psi." |
| X | The predicted position of the $CO_2$ plume and associated pressure front at site closure. | Figure 4.14 (p.232) | Map of maximum plume extent. |
| X | A description of post-injection monitoring locations, methods, and proposed frequencies. *This may include well locations; analytical methods and parameters; and sampling locations, formations/depths, and frequencies.* | Section 4.6.4 (p.234) | "As indicated in Table 4.4, the $CO_2$ plume and pressure front will be monitored after injection activities cease. Reservoir temperatures and pressures will be measured in injection wells. The extent of the plume will indirectly be measured with time-lapse 2D surveys. Data gathered from these two methods during post-injection will be used to validate the predicted plume model. If data differs from the predicted behavior, the model will be updated." |
| X | A proposed schedule for submitting post-injection site care monitoring results. | Section 4.6.5 (pp. 234-235)<br>Table 4.29 (p. 234) | "All data and analysis gathered during PISC monitoring activities will be submitted to WYDEQ and the EPA annually, within 60 days of the anniversary of injection cessation. The reports will contain groundwater data, storage reservoir pressures and temperature, seismic data, and any reservoir simulation results from new data." |
| X | The duration of the post-injection site care timeframe. | Section 4.6 (p. 225) | "To be conservative, High Plains plans to conduct post-injection monitoring for 50 years after injection ceases to confirm that the model does not show a risk of migration to the USDW or beyond the Project Site boundary." |
| X | The results of computational modeling of the AoR. | Figure 4.10 (p. 227)<br>Figure 4.11 (p. 228)<br>Figure 4.14 (p. 232) | Discussed in AOR section as well. |
| - | The predicted rate of $CO_2$ plume migration within the injection zone and the predicted timeframe for the cessation of migration. | Section 4.6.1 (pp. 229)<br>Figures 4.14 (p. 232) | "The rate of $CO_2$ migration within the injection zone is primarily controlled by structural dip, facies, porosity and permeability distribution. A discussion of these geological properties and their adaptation and inclusion in the $CO_2$ plume modeling is included in the application narrative. Figure 4.14 shows the pressures and $CO_2$ plume at end of injection, through stabilization and the end of PISC."<br>No rates reported. |
| | A description of the site-specific processes that will result in CO2 trapping. | Section 4.6 (pp. 229-230) | "At the end of the modeled timeframe (model year 2105), approximately 8.18 MMT of $CO_2$ is structurally trapped. Residual trapping stores 1.80 MMT. Solubility trapping accounts for approximately 0.61 MMT of $CO_2$ at the end of the model runtime. |
| - | The predicted rate of $CO_2$ trapping. | Section 4.6 (pp. 229-230) | No rates reported. |

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| X | The results of laboratory analyses, research studies, and/or field or site-specific studies to verify the above information. | Section 2 and Section 3 | Previously discussed in monitoring section. |
| X | A characterization of the confining zone(s), including a demonstration that it is free of faults and fractures and is sufficiently thick, and will impede fluid movement. | Section 2.4.2 including all subsections (pp. 99-118) | Previously discussed. |
| **X** | A description of the well's construction and an assessment of the quality of plugs of all abandoned wells in the AoR. | Section 3.3 (p. 158)<br>Table 3.10 (p. 168)<br>Section 3.5 (pp. 168-173) | Previously discussed. |
| X | The distance between the injection zone and the nearest USDWs. | Figure 2.2 (p. 41)<br>Figure 2.7 (p. 47)<br>Figure 2.8 (p. 48) | Previously discussed. |
| **EMERGENCY AND REMEDIAL RESPONSE PLAN** | | | |
| X | Proposed emergency and remedial response plan required by Section 25 (Chapter 24, Section 10(b)(xxxv)) | Section 4.1 (pp. 175-184) | |
| **FINANCIAL ASSURANCE** | | | |
| - | A demonstration, satisfactory to the Administrator, that the applicant has met the financial responsibility requirements of Section 26; (Chapter 24, Section 10(b)(xxix)) | Section 4.2 (pp. 184-188) | Monitoring and testing financial assurance is missing. |
| X | A written financial assurance cost estimate required by Section 26(b); (Chapter 24, Section 10(b)(xxx)) | Appendix G | Written financial assurance cost estimate provided in Appendix G. |
| - | A public liability insurance certificate that, in addition to meeting the requirements of W.S. § 35-11-313(f)(ii)(O), demonstrates that the public liability insurance policy meets the requirements of Section 26(l)(i)(B) of this Chapter; identifies each facility by name, address, and EPA Identification Number; and identifies the amounts and types of coverage for each facility; (Chapter 24, Section 10(b)(xxxi)) | Appendix G (p. 473) | Certificate is blank and needs to be completed prior to permit to construct. |

9 May 2024

Ms. Lily Barkau, P.G.
Groundwater Section Manager
Wyoming Department of Environmental Quality
Water Quality Division
200 West 17th Street, 2nd Floor
Cheyenne, WY 82002

*Submitted electronically:* WDEQ Water Quality Division Document Uploads (smartsheet.com) .

Dear Ms. Barkau:

Tallgrass High Plains Carbon Storage, LLC. has submitted a Response to Comments for the Barberry I-1, Azalea I-1, Cypress I-1, Spirea I-1 and Old Barberry I-1 Class VI UIC's. The main text and supporting attachments can be found in the secure SharePoint:

Comment Responses-Barberry, Azalea, Cypress, Spirea, Old Barberry

High Plains appreciates your continued support of this project.

Kind Regards,

*Pete Feutz*

Pete Feutz
Sr Compliance Geologist
Tallgrass Energy Partners, LP

**Underground Injection Control Carbon Sequestration**

**Class VI Permit Application**

**Eastern Wyoming Sequestration Hub**

**Permit Numbers 2023-039, 2023-264, 2023-041, 2023-263, 2023-040**

**Facility ID Numbers WYS-021-00153, WYS-021-00159, WYS-021-00155, WYS-021-00158, WYS-021-00154**

**Response to WDEQ Comments**

**May 10, 2024**

Prepared by:

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## RESPONSE TO SPECIFIC COMMENTS

### SPECIFIC COMMENT 1

***SC-1 WYDEQ Comment:***

*In accordance with Wyoming Water Quality Rules (WWQR), Chapter 24, Section 10 (b)(iv), please provide a completed Permit Application Form 1, Section 1 General Information, specifying the Facility Location Address. A proposed PLSS location and latitude and longitude may be used in absence of an actual street address.*

***SC-1 Response:***

Please see the completed Permit Application Form 1 documents for the Barberry I-1, Azalea I-1, Spirea I-1, Old Barberry I-1, Cypress I-1 permits in the "Form 1" folder in the Attachments to these Response to Comments. The proposed latitude and longitude coordinates represent the current approximation of the injection well placement and may deviate slightly once padsites are constructed. Finalized coordinates will be provided to WDEQ for review prior to construction of wells.

### SPECIFIC COMMENT 2

***SC-2 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 10(b)(viii), the applicant is required to provide a statement of whether the geologic sequestration project is within a state-approved water quality management plan area, a state-approved wellhead protection area or a state-approved source water protection area.*

a. *Tallgrass responded 'no' to Part 1, #4. Water Quality Management Plan, Wellhead Protection Area, Source Water Protection Area. However, Figure 3.6 shows that the Barberry I-1 is located within a wellhead protection area and a source water protection area. While conducting all operations associated with the Barberry Class VI Permit, please be aware that Tallgrass will be drilling through the primary aquifer for the Town of Pine Bluffs, Wyoming*
b. *Due to the Barberry well(s) being located within a wellhead protection area and a source water protection area, additional monitoring will be required.*
c. *Despite the Azalea I-1 not being located within the identified wellhead protection area and source water protection area for the Town of Pine Bluffs, Wyoming, please note the well's proximity (2-3 miles) to those areas. While conducting all operations associated with the Azalea Class VI Permit, please be aware that Tallgrass will be drilling through the primary aquifer for the Town of Pine Bluffs, Wyoming.*
d. *Due to the Azalea well(s) proximity to a wellhead protection area and a source water protection area, additional monitoring may be required.*
e. *Tallgrass responded 'no' to Part 1, #4 Water Quality Management Plan, Wellhead Protection Area, Source Water Protection Area. However, Figure 3.6 shows that the Old Barberry I-1 is located within a wellhead protection area and a source water protection area. While conducting all operations associated with the Old Barberry Class VI Permit, please be aware that Tallgrass will be drilling through the*

*primary aquifer for the Town of Pine Bluffs, Wyoming.*

*f. Due to the Old Barberry well(s) being located within a wellhead protection area and a source water protection area, additional monitoring will be required.*

***SC-2 Response:***

High Plains will ensure safe and diligent protection of all USDW's, particularly the primary aquifer for the town of Pine Bluffs, while conducting operations on all wells associated with the EWS Hub. Each drilled well will be cased and cemented to isolate the fresh water aquifers and wellbore integrity will verified through the use of cement bond logs (CBLs) and wireline borehole image tools.

High Plains recognizes the extra care needed to protect the wellhead protection area and the source water protection area and proposes the following monitoring plan per injection well location (Table 4.14 – revised):

- Direct groundwater sampling during baseline, injection, and post-operations periods
    - High Plains proposes to drill three shallow groundwater wells on each injection padsite and directly sample and test the following intervals:
        - Alluvium and Terrace deposits near surface
        - Ogallala, Arikaree and White River regional aquifers (High Plains Regional Aquifer System or Tertiary Aquifer System)
        - Lance and Fox Hills deposits*
            - *Periodic sampling during injection and post-operations will occur only if: a) local penetrations and water utility from this interval exist within the associated injection well $CO_2$ plume, or b) this interval is confirmed as the lowermost USDW in the project area, pending Baseline test results from respective injection wells.
- Soil Gas monitoring – direct sampling in proximity to each injection well
- Continuous Atmospheric/Surface Air monitoring with eddy covariance – one tower downwind (prevailing) of each injection well

**Table 4.14 — Baseline (pre-injection), operational, and post-operational monitoring. (Modified from Original Barberry I-1, Azalea I-1, Spirea I-1, Old Barberry I-1, Cypress I-1 permits)**

| Monitoring Type | Baseline (Pre-injection) | Operational | Post-Operational |
|---|---|---|---|
| **Soil Monitoring** | | | |
| Soil Gas Monitoring | Duration: 1 year<br>Frequency: Semi-Annual | Duration: During injection operations<br>Frequency: Semi-Annual | Duration: Until approved to cease monitoring<br>Frequency: Annual/ other frequency requested by DEQ |
| **Air Monitoring** | | | |
| Air Monitoring | Duration: 1 year<br>Frequency: Semi-Annual | Duration: During injection operations<br>Frequency: Semi-Annual | Duration: Until approved to cease monitoring<br>Frequency: Annual/ other frequency requested by DEQ |
| **Water Monitoring** | | | |
| Direct sample *three freshwater wells | Duration: 1 year<br>Frequency: Semi-Annual | Duration: During injection operations<br>Frequency: Semi-Annual | Duration: Until approved to cease monitoring<br>Frequency: Annual/ other frequency requested by DEQ |

**Fox Hills/Lance will only be periodically sampled during injection/PISC if a) local penetrations and water utility from this interval exist within the associated injection well $CO_2$ plume, or b) this interval is confirmed as the lowermost USDW in the project area.*

**SPECIFIC COMMENT 3**

***SC-3 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 10(b)(vi)(ix), please provide maps of the following or a statement that such entities do not exist within the AoR:*

*a. All state or EPA-approved cleanup sites*

*b. All surface bodies of water*

*c. Other pertinent surface features, including structures intended for human occupancy;*

***SC-3 Response:***

Please see the requested maps below that include surface structures, bodies of water, and EPA superfund sites in reference to the AoR. The water bodies comprise almost exclusively of small streams with minor ponds. No state or EPA-approved cleanup sites were identified within the AoR.

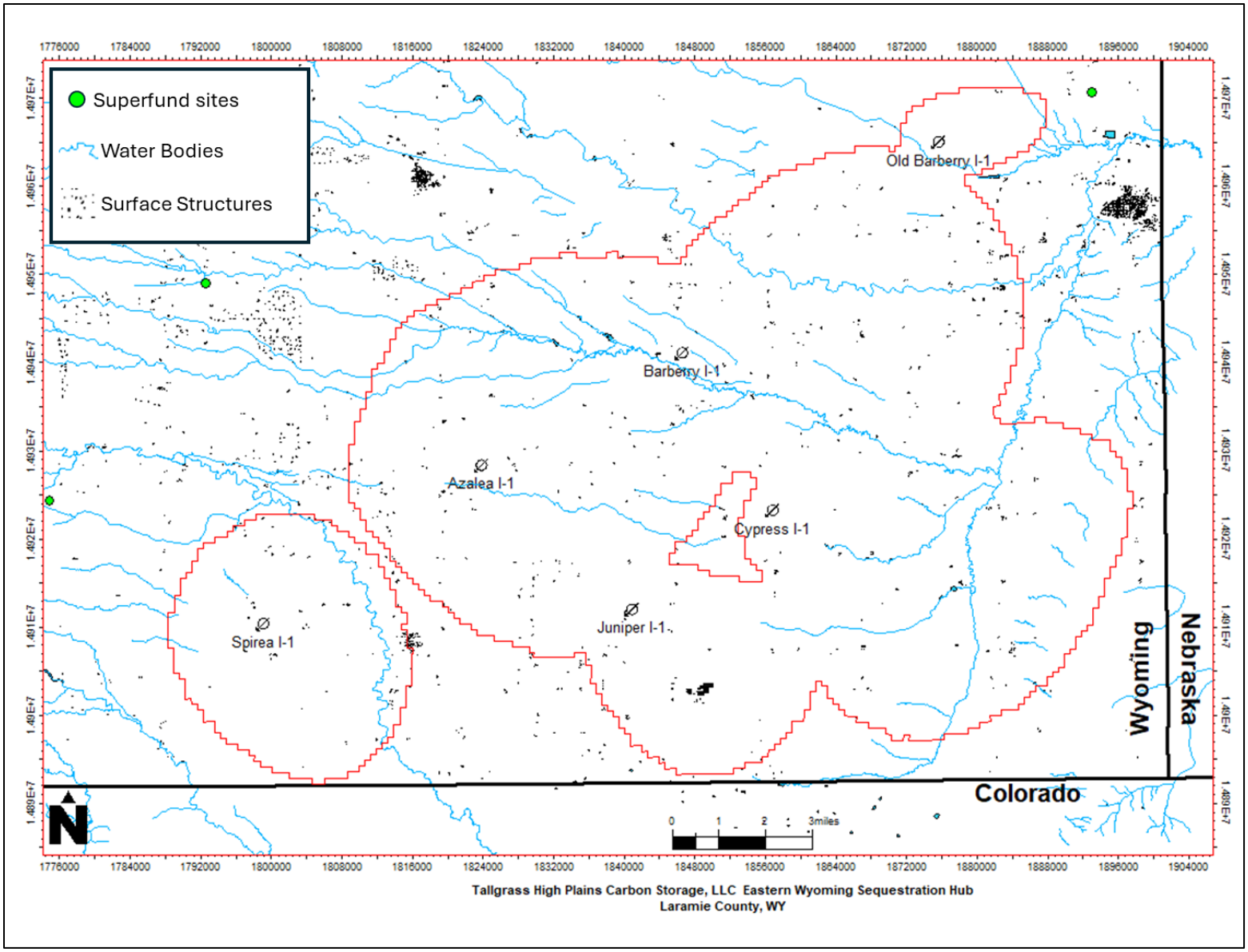



Figure RTC-1 – Map of surface structures, bodies of water and EPA superfund sites in proximity to the Barberry I-1, Cypress I-1, Old Barberry I-1, Spirea I-1, and Azalea I-1 AoR.

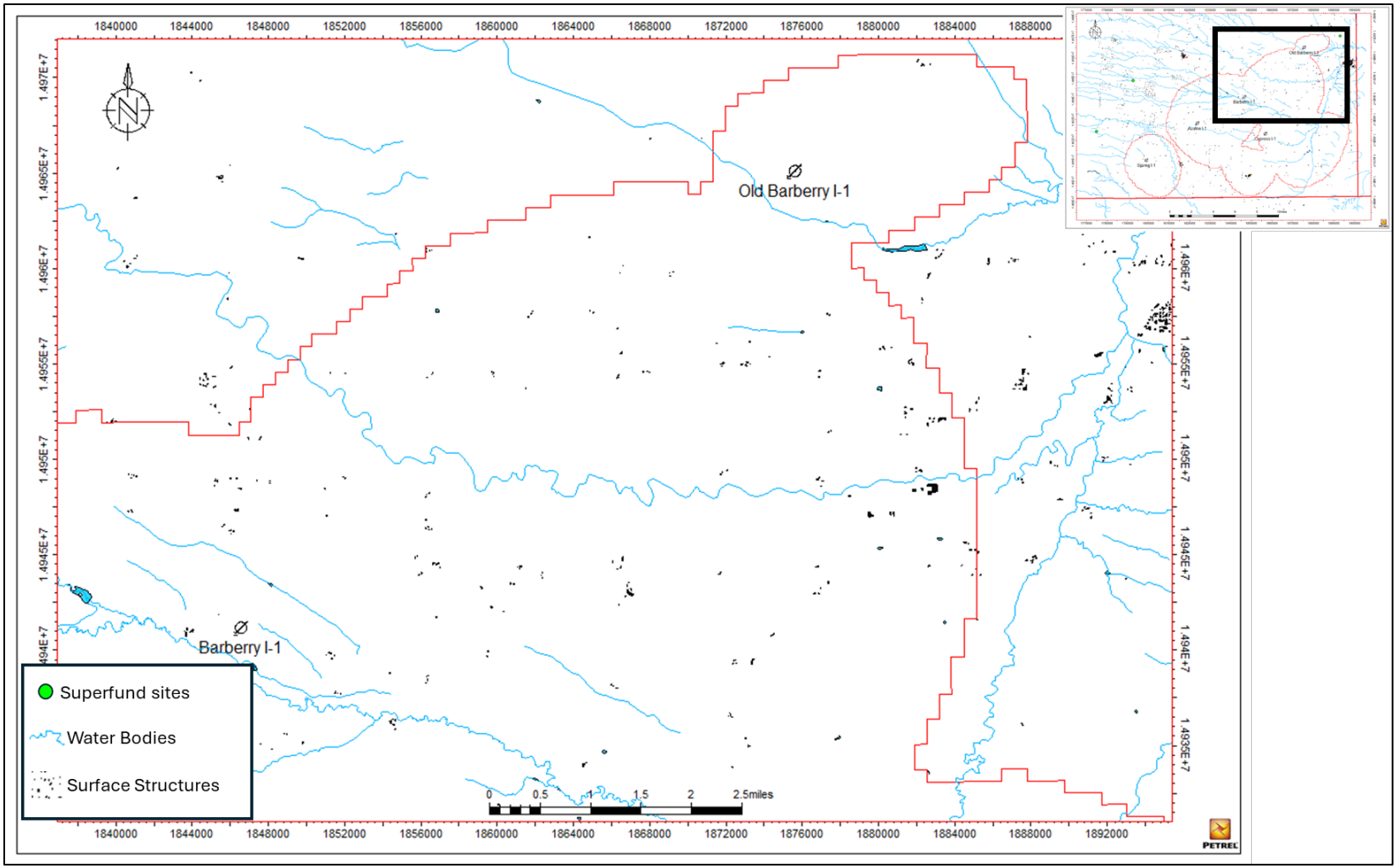



*Figure RTC-2 – Zoomed in map of surface structures, bodies of water and EPA superfund sites in proximity to the Old Barberry I-1 AoR.*

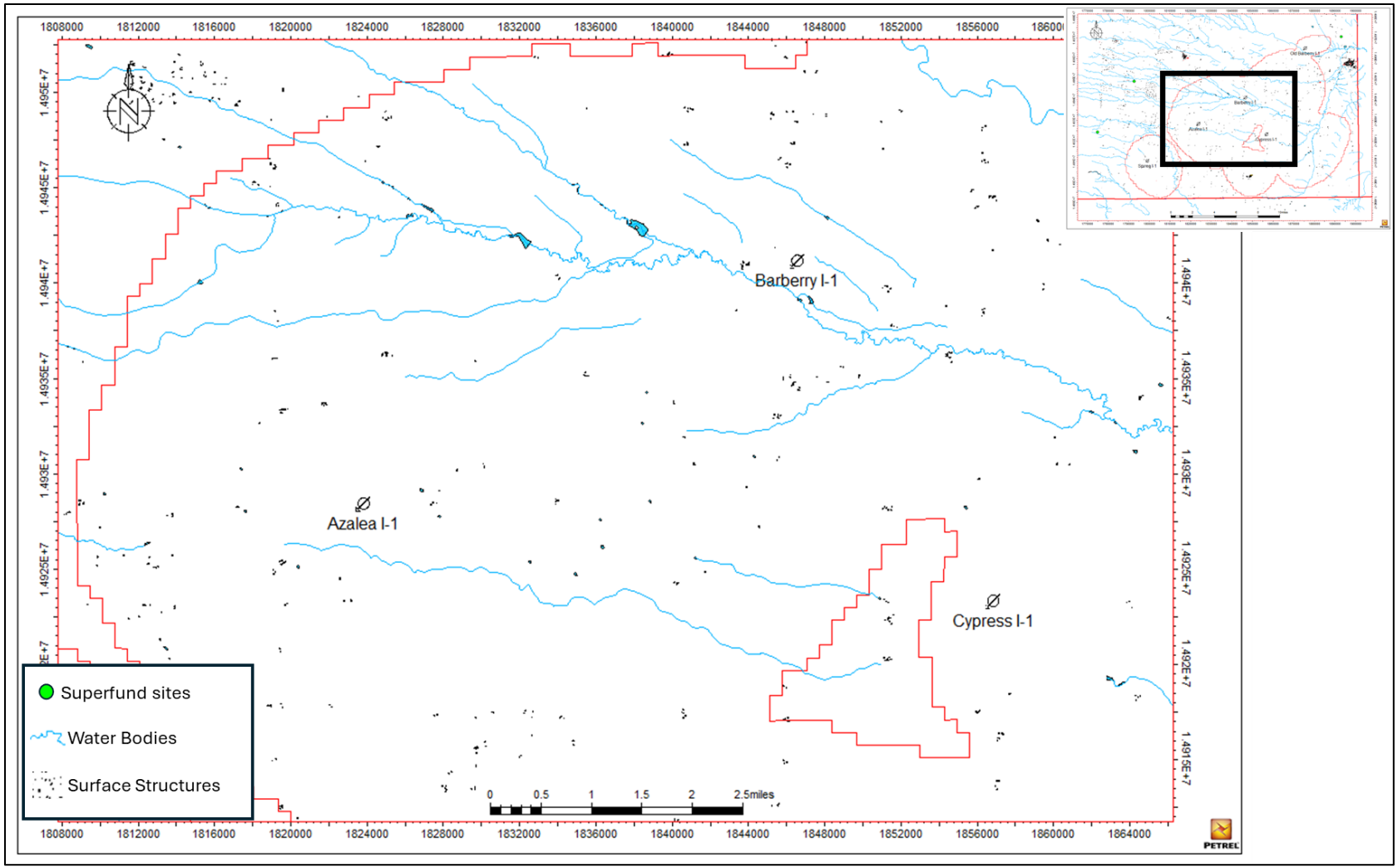



*Figure RTC-3 — Zoomed in map of surface structures, bodies of water and EPA superfund sites in proximity to the Barberry I-1 and Azalea I-1 AoRs.*

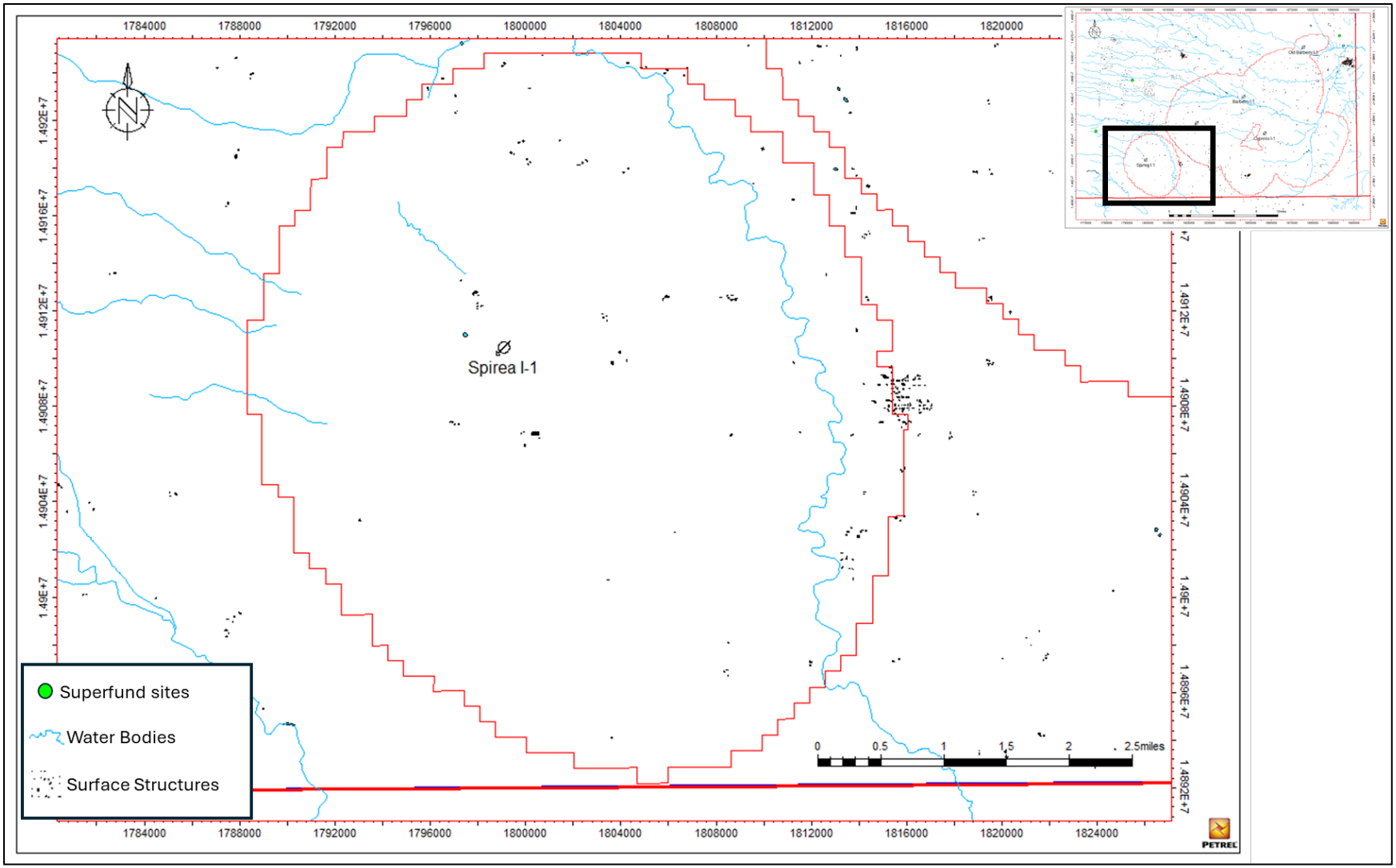



*Figure RTC-4 — Zoomed in map of surface structures, bodies of water and EPA superfund sites in proximity to the Spirea I-1 AoR.*

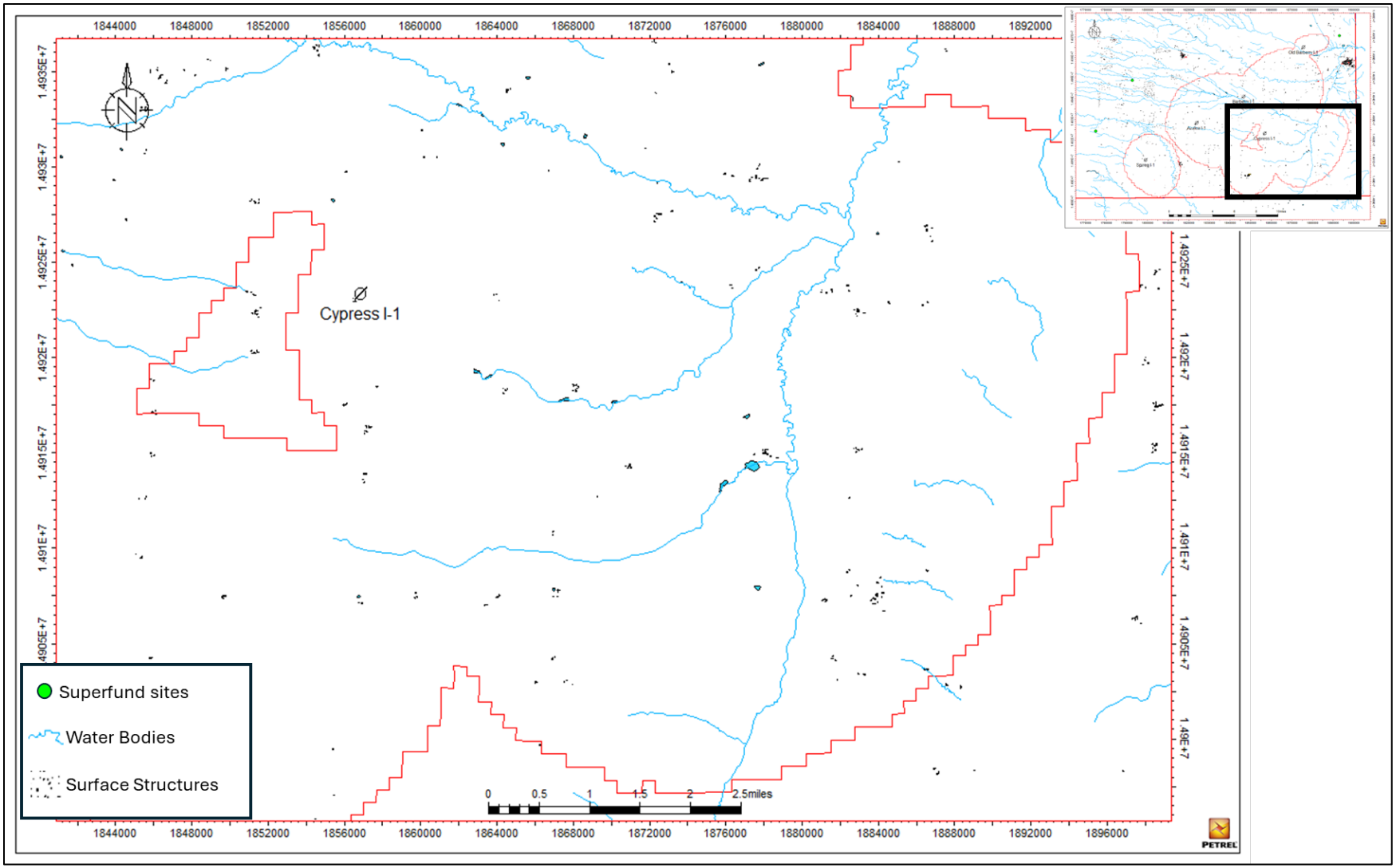



*Figure RTC-5 — Zoomed in map of surface structures, bodies of water and EPA superfund sites in proximity to the Cypress I-1 AoR.*

**SPECIFIC COMMENT 4**

***SC-4 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 10(b)(xi)(E), please provide the following geomechanical data:*

*a. Stress*
*b. Rock Strength*
*c. In situ fluid pressures*
*If this geomechanical data has not yet been collected, please provide a full, stepwise procedure for how this data will be collected for WDEQ review and approval.*

***SC-4 Response:***

Geomechanical data was collected from sampling the Lyons injection zone Juniper M-1 characterization well by means of whole core testing as well as downhole wireline testing using the SLB MDT tool.

Conventional core plug samples were taken from the whole core and geomechanical tests were conducted, such as unconfined compressive strength tests, triaxial compression tests, and Brazilian tensile strength tests. The resulting data included axial displacement/strain, force/axial strain, confining stress, radial deformation/strain and ultrasonic velocities, amongst others. The report from the laboratory vendor, Premier Corex, can be found in the Attachments folder associated with this submission titled “Juniper M-1 Rock Mechanics Data Report”.

The wireline SLB MDT tool was ran downhole in the Lyons formation and recorded in situ formation pressures. The MDT was unable to perform in the confining units due to very low permeability. This data can be found in the Attachments folder associated with this submission titled “Juniper M-1 MDT Results”.

High Plains intends to test for additional geomechanical properties in each injection well using the SLB MDT tool, or industry equivalent, and cores, as outlined in Table 4.21 of the respective permits. The targeted formations will include the Lyons injection zone as well as the confining units of Goose Egg/ Chugwater and Satanka. Details for these sampling procedures can be found in Specific Comment 5.

**SPECIFIC COMMENT 5**

***SC-5 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 10(b)(xix), please provide procedures for the formation testing programs to be done in the Barberry I-1 and M-1; Azalea I-1 and M-1; Spirea I-1 and M-1; Old Barberry I-1 and M-1; Cypress I-1 and M-1.*

***SC-5 Response:***

High Plains plans to test key formations in both the injection wells (I-1 wells) and associated monitoring wells (M-1 wells). The sections below highlight similarities and differences to how

each well is being approached for formation characterization. Any references to data collection from the lower confining unit (Satanka) is supported with an explanation for the need to extend the wellbore below the injection zone in the *Proposed Changes and Updates* section at the end of this document.

**Injection Wells (Barberry I-1, Azalea I-1, Spirea I-1, Old Barberry I-1 and Cypress I-1)**

High Plains proposes to perform formation testing on each injection well as summarized in Table 4.21 and the following sections.

**Table 4.1 — Barberry I-1, Azalea I-1, Spirea I-1, Old Barberry I-1 and Cypress I-1 proposed logging programs. (Modified from Original Barberry I-1, Azalea I-1, Spirea I-1, Old Barberry I-1, Cypress I-1 permits)**

| Hole Section | Trip | Logging Suite | Target Data Acquisition |
|---|---|---|---|
| Surface 0 ft to 1,500 ft (Open Hole) | S1 | Gamma Ray | Identification of Rock Properties |
| | | Caliper | |
| | | Resistivity | |
| | | Density | |
| | | Neutron | |
| | | Sonic/Acoustic | |
| Surface 0 ft to 1,500 ft (Cased Hole) | S2 | Cement Bond Log w/VDL display | Annular cement placement and bond quality |
| | S3 | Temperature Log | |
| Pilot 1,500 ft to TD (Open Hole) | P1 | Resistivity | Identification of Rock Properties |
| | | Density | |
| | | Neutron | |
| | | Gamma Ray | |
| | | Gamma Ray | Log tie back |
| | | Deviation Survey | Wellbore position |
| | | Multi-arm Caliper | Aid in Cement Calcs |
| | | Sonic/Acoustic | Mechanical Properties and Synthetic Ties |
| | P2 | Oil-based Image Log | Fracture/Fault/Structure |
| | P3 | Ultrasonic Image Log | |
| | P4 | MDT or equivalent | Formation Fluid Samples, Pressure Measurements |
| | P5 | Whole Core or Sidewall Coring tool | Direct rock testing |
| | | Gamma Ray | Log tie back to previous runs |
| Pilot 1,500 ft to TD (Cased Hole) | P6 | Cement Bond Log | Well Integrity Baseline |
| | P7 | Temperature Log | Mechanical integrity baseline |
| | P8 | Magnetic Flux / Casing Inspection Log | |

**SLB Modular Formation Dynamics Tester (MDT)**

High Plains will utilize the SLB Modular Formation Dynamics Tester (MDT) wireline tool (or equivalent) to gather fluid samples, in-situ pressure measurements, and fracture gradients in relevant formations (Table RTC-1). Further details on the MDT tool specs can be found in Appendix E, Attachment E-4 of each respective permit.

As a contingency to the MDT tool, High Plains will be prepared to utilize the Single-phase Reservoir Sampler (SRS, spec details in Attachments folder "*SLB SRS Specs*"). Should the SRS also fail to collect the required fluid samples, then a Drill Stem Test will be utilized to collect the fluid samples.

The targeted permeable formations for fluid sampling include the Sundance Formation, the Hygiene member of the Pierre Shale, and the Lyons Formation. The MDT tool ensures virgin reservoir fluid using its pump-out module, live-fluid analyzer (LFA) module and the flowline resistivity measurement to identify and to collect high-quality reservoir fluid samples suitable for further laboratory analyses. High Plains will also collect and test samples of the brine used to create the drilling fluid. The formation fluid brine chemistry allows for further quality assurance to help determine if there is any contamination of the downhole samples.

In situ pressure measurements will be undertaken in the Hygiene, Sundance and Lyons and attempts will be made to test the confining zones (Chugwater, Goose Egg and Satanka), although this may be difficult due to the MDT tool's challenges measuring pressure in low permeability rock. Reservoir pressure measurements using the MDT require inserting the probe into the reservoir and withdrawing a small amount of fluid, so low permeability will restrict fluid movement and sampling.

Fracture gradients and in situ stress of the injection zone (Lyons) and confining zones (Goose Egg/Chugwater and Satanka) will be measured using the minifrac module on the MDT tool, in order to satisfy *Ch.24 Sec. 17(d)* that states that *"The owner or operator shall determine fracture pressures of the injection and confining zones…".*

**Table RTC-1. Summary of MDT sampling and testing plan.**

| MDT Testing | | | |
|---|---|---|---|
| **Formation** | **Water Sample** | **Formation Pressure** | **Fracture Gradient** |
| Hygiene | X | X | |
| Sundance | X | X | |
| Chugwater/ Goose Egg | | | X |
| Lyons | X | X | X |
| Satanka | | | X |

**Deep USDWs**

Procedure: Wireline SLB MDT tool run in injection well, isolate targeted formation with swelling packers, collect pressurized samples downhole, return tool to surface, remove water capsules from MDT tool and deliver to EPA-certified laboratory for analysis.

- Hygiene
- Sundance
- Lyons

**Shallow USDWs – Groundwater Sampling**

High Plains proposes to directly sample shallow USDWs from three shallow groundwater wells that High Plains will drill on each injection well pad site. Water pumps will be utilized in each well and will pump water to surface for collection. Water containers will be transported with a chain of custody to an EPA-certified laboratory for analysis. Targeted intervals include:

- Alluvium and Terrace deposits near surface
- Ogallala, Arikaree and White River regional aquifers (High Plains Regional Aquifer System or Tertiary Aquifer System)
- Lance and Fox Hills deposits

**Core: Whole Core or Sidewall Cores**

To verify rock properties observed from the whole core High Plains collected from the Juniper M-1 characterization well, whole core or sidewall cores will also be collected from each injection well. Coring will target the confining units (Goose Egg/Chugwater and Satanka) and the injection zone (Lyons). The locations of core points will be determined by detailed interpretation of wireline log data from either the Juniper M-1 (if taking whole core) or the corresponding injection well (if taking sidewall cores) and will align with what High Plains interprets as the best representation of the respective formation's facies and range of rock properties. High Plains estimates that this translates to approximately 100-200 feet of whole core or roughly 5-10 sidewall core samples across the sealing formations (Goose Egg and Satanka) and one sidewall sample every 10 feet from the Lyons injection zone. Core laboratory analysis will include routine core analysis (RCA) in the Lyons to establish porosity, permeability, grain density, and saturation, tight rock analysis (TRA) in the Goose Egg and Satanka to establish porosity, permeability, grain density, and saturation, mercury injection/capillary pressure (MICP) drainage/imbibition for all zones to establish pore throat distribution and sealing capacity calculations, and threshold entry pressure measurements where possible.

**Pressure Fall-Off Testing**

Per the requirements of WYDEQ *Chapter 24 §17(d) and §20(b)(vii),* High Plains will conduct a baseline pressure fall-off test before initial injection and then every five years thereafter (*Section 4.3.1.1 Injection Well Integrity Tests of each respective permit application)*. The data provided from these tests will be used to measure formation properties near the injection well and monitor for any near-wellbore environment changes that may impact injectivity and increase pressures.

Testing Method

The injection rate and pressure for the well will be consistently maintained and continuously recorded before the pressure fall-off test begins. Once the well is shut in, continuous pressure measurements will be recorded from two BHP gauges. The second gauge will be used as a backup and for verification in the event of data inconsistencies. The fall-off period will continue until radial flow conditions are observed, as indicated by a straight line of pressure decay on a semi-log plot.

Analytical Methods

The calculation of specific near-well bore conditions, including well skin, prevailing flow regimes, and hydraulic property and boundary conditions, will be determined from standard diagnostic log-log and semi-log plots. Performing baseline pressure fall-off testing before injection allows for future comparison of subsequent tests and indicates whether significant changes in the well or reservoir conditions have occurred. Such analysis will consider the impact of two-phase flow effects. The parameters determined from the fall-off tests will be compared to those used in the site computational modeling and AoR determination. The AoR will be reevaluated if any significant changes in reservoir properties are identified.

Quality Assurance/Control

All field equipment will be inspected and tested before use, and the pressure gauges used in the fall-off test will be calibrated per manufacturers' recommendations. Calibration certificates will be provided with the test results. The use of the second BHP gauge will provide further validation of the test results.

The results of the pressure fall-off tests will be submitted to the Administrator within 30 days of the test.

**Mechanical Integrity Testing – Annulus Pressure Test**

Per the requirements of WYDEQ *Chapter 24 §19(b)*, High Plains will perform internal mechanical integrity tests (MITs) before initial injection and after any subsequent workovers (*Section 4.3.1.1 Injection Well Integrity Tests of each respective permit application)*. These annular pressure tests will be performed to demonstrate the mechanical integrity of the casing, tubing, and packer at the initial completion and after any workovers.

Testing Procedure

The annulus between the casing and tubing will be pressured to a minimum of 500 psi (fluid pressure). Once the test has started, a block valve will be used to isolate the test pressure source from the test pressure gauge, and all the ports into the casing annulus will be closed except the one used for monitoring the test pressure gauge. The test pressure will be monitored and recorded for a minimum of 30 minutes. A loss of test pressure greater than 10% during the minimum 30 minutes will indicate a potential lack of mechanical integrity and will be further reviewed for mitigation needs. The pressure gauge used during the test will be sensitive enough to show a loss of 10%.

The results of this annulus pressure test will be reported to the Administrator within 30 days of the test.

**Above Zone Monitoring Wells (Barberry M-1, Azalea M-1, Spirea M-1, Old Barberry M-1 and Cypress M-1)**

High Plains also intends to perform formation testing on each above-confining zone monitoring well (M-1 well) associated with the respective injection well (Barberry I-1, Azalea I-1, Spirea I-1, Old Barberry I-1 and Cypress I-1), as summarized in Table 4.26. The wireline logging tools will be run very similarly as the injection wells; however, High Plains would like to emphasize a notable difference in that core sampling and MDT testing/sampling (fluid samples, formation pressure, fracture gradient) will be contingent on the successful characterization program of the injection wells. This is to reduce redundancy on wells that will be spaced approximately 200 feet apart, meaning that if High Plains successfully captures core data and MDT data from the injection well, it will be unnecessary to attempt the same tests on the subsequent M-1 wells.

**Table 4.2— Proposed logging plan for Barberry M-1, Azalea M-1, Spirea M-1, Old Barberry M-1, and Cypress M-1. (Modified from Original Barberry I-1, Azalea I-1, Spirea I-1, Old Barberry I-1, Cypress I-1 permits)**

| Hole Section | Trip | Logging Suite | Target Data Acquisition |
|---|---|---|---|
| Surface 0 ft to 1,500 ft (Open Hole) | S1 | Gamma Ray | Identification of Rock Properties |
| | | Caliper | |
| | | Resistivity | |
| | | Density | |
| | | Neutron | |
| | | Sonic/Acoustic | |
| Surface 0 ft to 1,500 ft (Cased Hole) | S2 | Cement Bond Log w/VDL display | Annular cement placement and bond quality |
| | S3 | Temperature Log | |
| Pilot 1,500 ft to TD (Open Hole) | P1 | Resistivity | Identification of Rock Properties |
| | | Density | |
| | | Neutron | |
| | | Gamma Ray | |
| | | | Log tie back |
| | | Deviation Survey | Wellbore position |
| | | Multi-arm Caliper | Aid in Cement Calcs |
| | | Sonic/Acoustic | Mechanical Properties and Synthetic Ties |
| | P2 | Oil-based Image Log | Fracture/Fault/Structure |
| | P3 | Ultrasonic Image Log | |
| | P4 | *MDT or equivalent | Formation Fluid Samples, Pressure Measurements |
| | P5 | *Whole Core or Sidewall Coring tool | Direct rock testing |
| | | Gamma Ray | Log tie back to previous runs |
| Pilot 1,500 ft to TD (Cased Hole) | P6 | Cement Bond Log | Well Integrity Baseline |
| | P7 | Temperature Log | Mechanical integrity baseline |
| | P8 | Magnetic Flux / Casing Inspection Log | |

**Will only be executed on M-1 wells if coring and MDT sampling is unsuccessful on the respective injection wells.*

High Plains will provide WDEQ the opportunity to witness all logging and testing and will submit a schedule of such activities to WDEQ prior to conducting the first test and will notify WDEQ of any changes to the schedule thirty (30) days prior to the next scheduled test.

**SPECIFIC COMMENT 6**

***SC-6 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 10(b)(xx), a detailed stimulation plan will need to be submitted for WDEQ's review and approval prior to issuance of authorization to inject under a modified permit. If the stimulation is to be done under the Permit to Construct as part of formation testing, this plan needs to be submitted with a response to these comments for WDEQ's review and approval prior to issuance of the Permit to Construct.*

***SC-6 Response:***

At this time, High Plains does not currently plan to stimulate the injection wells.

As noted in 4*.3.13 Reporting and Notice Requirements* of the respective permits, High Plains will submit stimulation plans for DEQ approval and notify the Administrator, in writing, 30 days before:

- Any planned well workover;
- Any planned stimulation activities, other than stimulation for formation testing; or
- Any other planned test of the injection well conducted by High Plains.

High Plains does plan to perform an in-situ pressure test utilizing a modular formation dynamic tester (MDT) during formation evaluation wireline activities for the injection well, as outlined in Specific Comment 5. This consists of pumping a small volume of water (<40 gallons) between two downhole packers, spaced 3.281ft apart and observing a microscopic closure.

**SPECIFIC COMMENT 7**

***SC-7 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 13(c)(i-iv), please provide a discussion of how Tallgrass will re-evaluate wells for corrective action within an adjusted AoR.*

***SC-7 Response:***

High Plains will regularly reevaluate the AoR and corrective action plan, per the requirements of WYDEQ Chapter 24 §13(c), at least every two years during the operational life of the EWS Hub and every five years during the post-injection site care period (until site closure) – or when monitoring and operational conditions warrant a reevaluation prior to the next scheduled reevaluation.

AoR and corrective action reevaluations during regularly scheduled events include but are not limited by the following:

- Review collected monitoring data and compare to the existing computational model results. Monitoring and operational data from the injection and monitoring wells will be assessed to determine whether the predicted $CO_2$ plume migration is consistent with actual data. This workflow includes reviews of:

- Groundwater chemistry monitoring data taken in the monitoring wells to verify that $CO_2$ or non-native brine has/has not invaded and endangered any USDWs.
- Available data on the position of the $CO_2$ plume and pressure front, including pressure and temperature monitoring data and pulsed neutron log (PNL) saturation and seismic survey data. Activities will include:
    - Reviewing downhole reservoir pressure and temperature data collected from the injection wells using a combination of surface and downhole pressure gauges.
    - Operational changes such as injection rates and pressures, to verify that these data are consistent with the inputs used in the most recent modeling simulation.

If the new monitoring and operating data reviewed is consistent with the most recent modeling assumptions and is not expected to materially influence the modeled extent of plume and pressure front movement, no reevaluation of the AoR will be undertaken. A report will be generated and submitted with the next scheduled semiannual report for WDEQ review and approval. The report will include the data and results demonstrating that no changes are necessary. If material changes have occurred, then the conceptual model will be updated with the new data and a report will be submitted with the next scheduled semiannual report for WDEQ review and approval. This report will include comparisons between the previous simulation and the updated version, details of potential corrective action and a current status of the corrective action. High Plains will then prepare for a permit modification where the AoR and Corrective Action Plan will be updated to reflect the revised AoR, along with other related project plans, as needed.

AoR reevaluations prior to the next scheduled reevaluation may also be warranted. Should this occur, the same steps as listed above will be undertaken to initiate reporting and corrective action as necessary. Examples of occurrences that could trigger a reevaluation of the AoR prior to the next schedules update include but are not limited to:

- Planned changes to maximum injection rate and/or duration that would extend the simulated AoR.
- Changes to the composition of the injectate to a mixture that extends the simulated AOR.
- New or re-interpreted site characterization data, such as core-derived petrophysical data, that extends the simulated AoR.

**SPECIFIC COMMENT 8**

***SC-8 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 10(b)(xxxiii), the well plugging plan requires the type, grade, and quantity of material to be used in well plugging to be submitted. Additionally,*

*please provide information on how these materials meet or exceed the American Petroleum Institute standards per WWQR Chapter 24, Section 14(b)(i).*

***SC-8 Response:***
**Cementing Section**

Pertaining to the plug and abandonment (P&A) cementing operations prescribed in *CH24, Section 10(b)(xxxiii),* the utilization of $CO_2$-resistant cement is proposed, with specific attention to the EverCRETE system by SLB (or commercial equivalent) for the main cement plug across the injection zone. EverCRETE product specifications can be seen in the Attachments folder as "EverCRETE_SLB_Specs". The cement plug design will ensure the placement of the top of the cement plug at least 250 feet above the top of the injection zone formation and 100 feet below the base of the injection formation. This approach not only meets but exceeds the requirement for recreating seal zones, ensuring well integrity and environmental protection.

**Technical Specifications:**

- *Cement Type*: High-grade $CO_2$-resistant cement (Reduced Portland + proprietary blend), compatible with EverCRETE technology (or commercial equivalent), ensuring durability and resistance to $CO_2$ degradation.
- *Plug Placement & Verification*: Cement plugs for Plug & Abandonment will be placed utilizing the balanced plug method. Engineered heavy pills will separate each plug to minimize cement contamination and optimize zonal isolation. Injection zone cement plug will be tagged, and placement verified with 10,000lbs of weight, after minimum 500psi cement compressibility reached.
- *Injection Zone Perforations*: Perforations will be squeezed with $CO_2$ resistant cement prior to cement plug placement if reservoir conditions allow.
- *Quantity*: The quantity will be determined based on the wellbore dimensions, injection zone characteristics, and the required cement column height as per the design criteria mentioned. Assuming pre-drilling injection well characteristics, the following volumes can be assumed for injection zone P&A design.
    - Barberry I-1 Lyons Cement Plug Volumes: **Injection Zone 9064ft-9120ft**
        - 406ft Cement Plug | Minimum of 233 sacks of Acid Resistant Cement
    - Old Barberry I-1 Lyons Cement Plug Volumes: **Injection Zone 8616ft-8688ft**
        - 422ft Cement Plug | Minimum of 242 sacks of Acid Resistant Cement
    - Cypress I-1 Lyons Cement Plug Volumes: **Injection Zone 8951ft-9010ft**
        - 409ft Cement Plug | Minimum of 235 sacks of Acid Resistant Cement
    - Spirea I-1 Lyons Cement Plug Volumes: **Injection Zone 9447ft-9511ft**
        - 414ft Cement Plug | Minimum of 238 sacks of Acid Resistant Cement
    - Azalea I-1 Lyons Cement Plug Volumes: **Injection Zone 9349ft-9410ft**

- 411ft Cement Plug | Minimum of 236 sacks of Acid Resistant Cement

- *EverCRETE Cement Specifications:*

| Density [ppg] | Yield [$ft^3$/sk] | Mix Water [gal/sk] | Permeability [mD] | Compressive Strength [psi] |
|---|---|---|---|---|
| 15.8 | 1.12 | 3.43 | <0.1 | >1000 |
| 14.5 | 1.22 | 3.73 | <0.1 | >1000 |
| 12.5 | 1.58 | 5.15 | <0.1 | >1000 |

- Standards Compliance: The selected cement will comply with API standards for high-pressure, high-temperature wells, ensuring the cement's mechanical properties are suitable for the intended application.

**Casing Section**

The injection zone casing incorporates the use of Chrome 13 (or superior) casing material. This choice reflects a commitment to high-quality materials that provide exceptional strength, corrosion resistance, and longevity, vital for the structural integrity of Class VI injection wells.

**Technical Specifications:**

- Casing Material: Chrome 13 or better, offering high corrosion resistance and strength to withstand the harsh conditions of $CO_2$ sequestration environments. Chrome casing will cover entire injection zone and up to at least injection packer.
- Tubular Connection: All tubular connections will be gas tight connections.
- Standards Compliance: The casing will meet or exceed API specifications, including but not limited to API Spec 5CT for the manufacture of casing and tubing, ensuring optimal performance and safety.

**Compliance and Standards**

The proposed materials and methods rigorously adhere to API standards, specifically those concerning materials' quality, strength, and durability necessary for well integrity in $CO_2$ sequestration applications. The API's comprehensive standards ensure that the materials used in well P&A operations are of the highest quality, contributing to the long-term stability and safety of the well.

In summary, the well plugging plan is designed with a conservative approach, prioritizing well integrity, environmental protection, and regulatory compliance. Utilizing $CO_2$-resistant cement, EverCRETE technology (or commercial equivalent) for cement plugs, and Chrome 13 or better casing material ensures the well plugging operations exceed the American Petroleum Institute standards, aligning with the requisites of WWQR Chapter 24, Sections 10(b)(xxxiii) and 14(b)(i). This approach underscores a commitment to safety, environmental stewardship, and adherence to both state and federal guidelines.

**SPECIFIC COMMENT 9**

***SC-9 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 24(a)(ii)(K), the predicted rate of CO2 plume migration within the injection zone is required.*

***SC-9 Response:***

During the field-wide 30-year injection period (year 2025 to 2055) the Barberry I-1, Cypress I-1, Old Barberry I-1, Spirea I-1, Azalea I-1 wells will all have cycled through their respective injections periods (injection durations vary from well to well during that 30 years). The predicted rate of $CO_2$ plume areal migration within the injection zone decreases from 5.2 $mi^2$/year at the start of field-wide injection (2025) to 2.9 $mi^2$/year at the end of injection (2055). The plume areal extent in year 2055 for the Barberry I-1, Cypress I-1, Old Barberry I-1, Spirea I-1, Azalea I-1 wells (and Juniper I-1) can be seen in Figure RTC-6. During PISC, from year 2055 to 2105, the predicted rate of $CO_2$ plume migration averages at 0.9 $mi^2$/year until the plume stabilizes (Figure RTC-7).

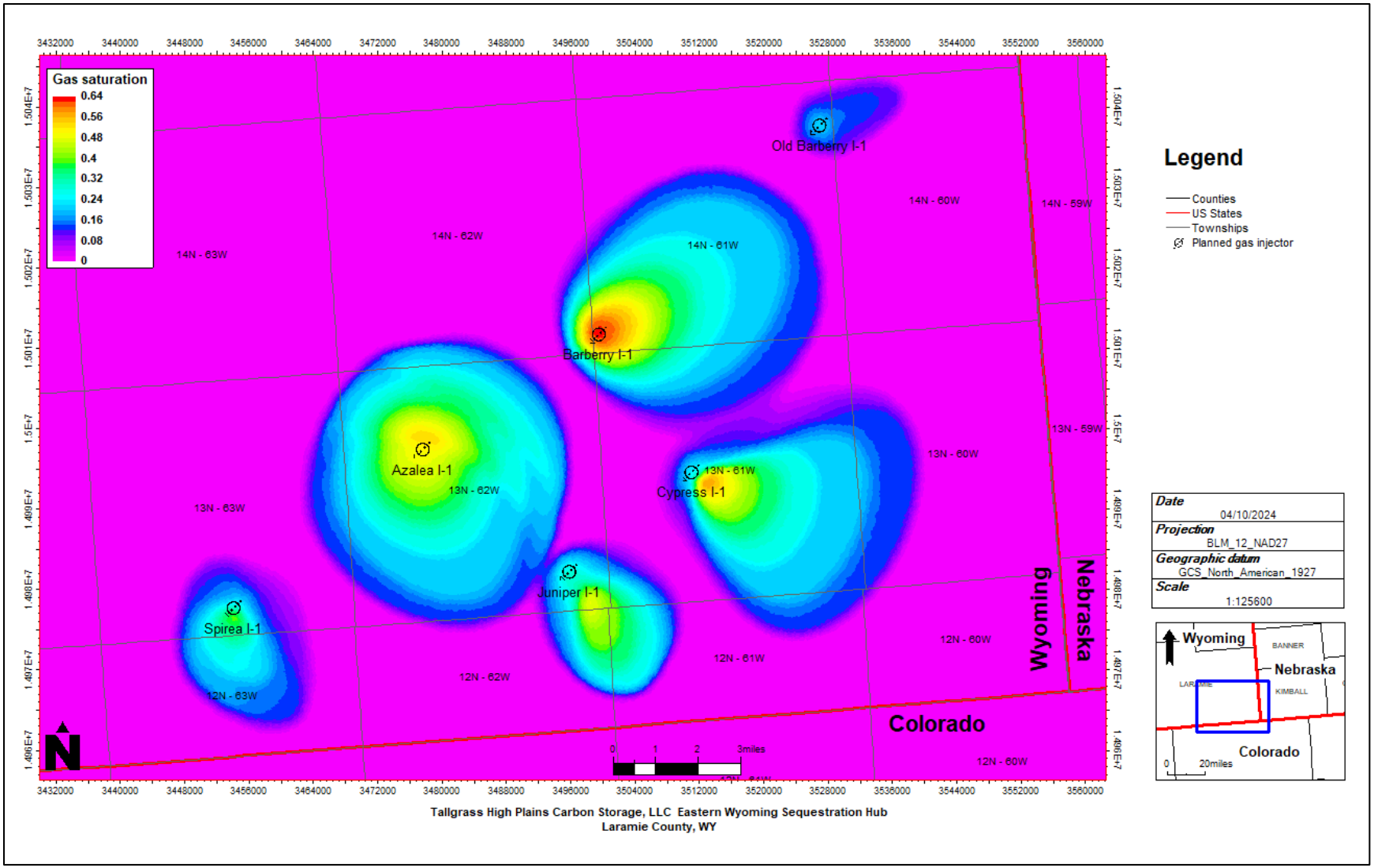



*Figure RTC-6 - Extent of Barberry I-1, Cypress I-1, Old Barberry I-1, Spirea I-1, Azalea I-1 plumes (including Juniper I-1) in year 2055, 30-years after first injection.*

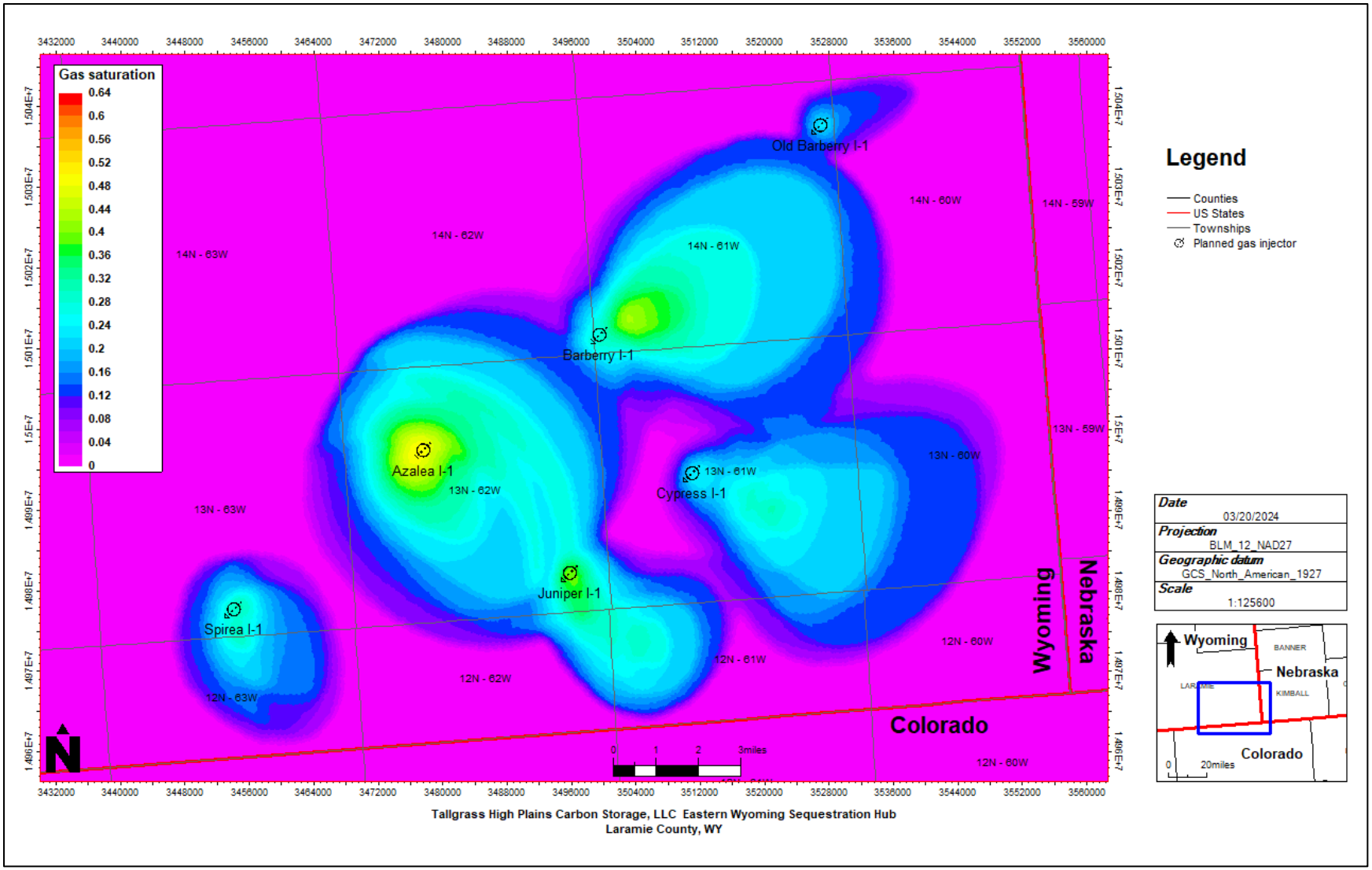



*Figure RTC-7 - Extent of Barberry I-1, Cypress I-1, Old Barberry I-1, Spirea I-1, Azalea I-1 (including Juniper I-1) plumes in year 2105 at plume stabilization.*

Once injection ceases in year 2055, $CO_2$ plume stabilization occurs 50 years post-injection in 2105, per WDEQ's Sec. 2(hh) definition where "*plume stabilization has been achieved when the carbon dioxide stream that has been injected subsurface essentially no longer expands vertically or horizontally and poses no threat to underground sources of drinking water, human health, safety, or the environment, as demonstrated by a minimum of three (3) consecutive years of monitoring data*". Figure RTC-8 shows the final years of plume migration in 3-year increments. At this point, $CO_2$ plume migration has ceased.

In the original permit submissions, High Plains proposed a 50-year PISC period for plume stabilization for all wells within the EWS Hub. Upon further review, High Plains recognizes the need to extend the individual PISC period for Old Barberry, Spirea, Azalea, and Cypress injector wells. The current subsurface understanding of the EWS Hub is that there are no permeability barriers between the respective injector wells; thus, the pressure fronts are in geologic communication during injection and PISC periods until all EWS Hub plumes have ceased injection and have reached stabilization. Please note that High Plains anticipates a PISC period of ~20-30 years per well, but as a prudent operator has extended the PISC period to a minimum of 50 years. Thus, the PISC timeframe must be extended beyond 50 years for most of the wells to account for Barberry and Azalea pressure influences as these two wells are on injection for longer time periods. The extended PISC periods account for an 80-year period for the life of the field. Please reference the column titled "Post Injection Site Care (Years)" in Table RTC-2 for the per well amended PISC periods.

**Table RTC-2. New proposed Post-Injection Site Care (PISC) periods. * Note that the Juniper I-1 permit will later be amended to accommodate for the additional plumes.**

| Injection Details | | | | | | |
|---|---|---|---|---|---|---|
| **Plume** | **Total Sequestered Volume (MMT)** | **Injection Begins (Year)** | **Injection Ends (Year)** | **Injection Total (Years)** | **Plume Stabilization (Year)** | **Post Injection Site Care (Years)** |
| **Old Barberry** | 2 | 2025 | 2026 | 1.5 | 2105 | 78.5 |
| **Barberry** | 38 | 2025 | 2055 | 30 | 2105 | 50 |
| **Spirea** | 11 | 2025 | 2040 | 15 | 2105 | 65 |
| **Azalea** | 45 | 2025 | 2055 | 30 | 2105 | 50 |
| **Cypress** | 29 | 2025 | 2048 | 24 | 2105 | 56 |
| **Juniper*** | 12 | 2025 | 2045 | 20 | 2105 | 60 |

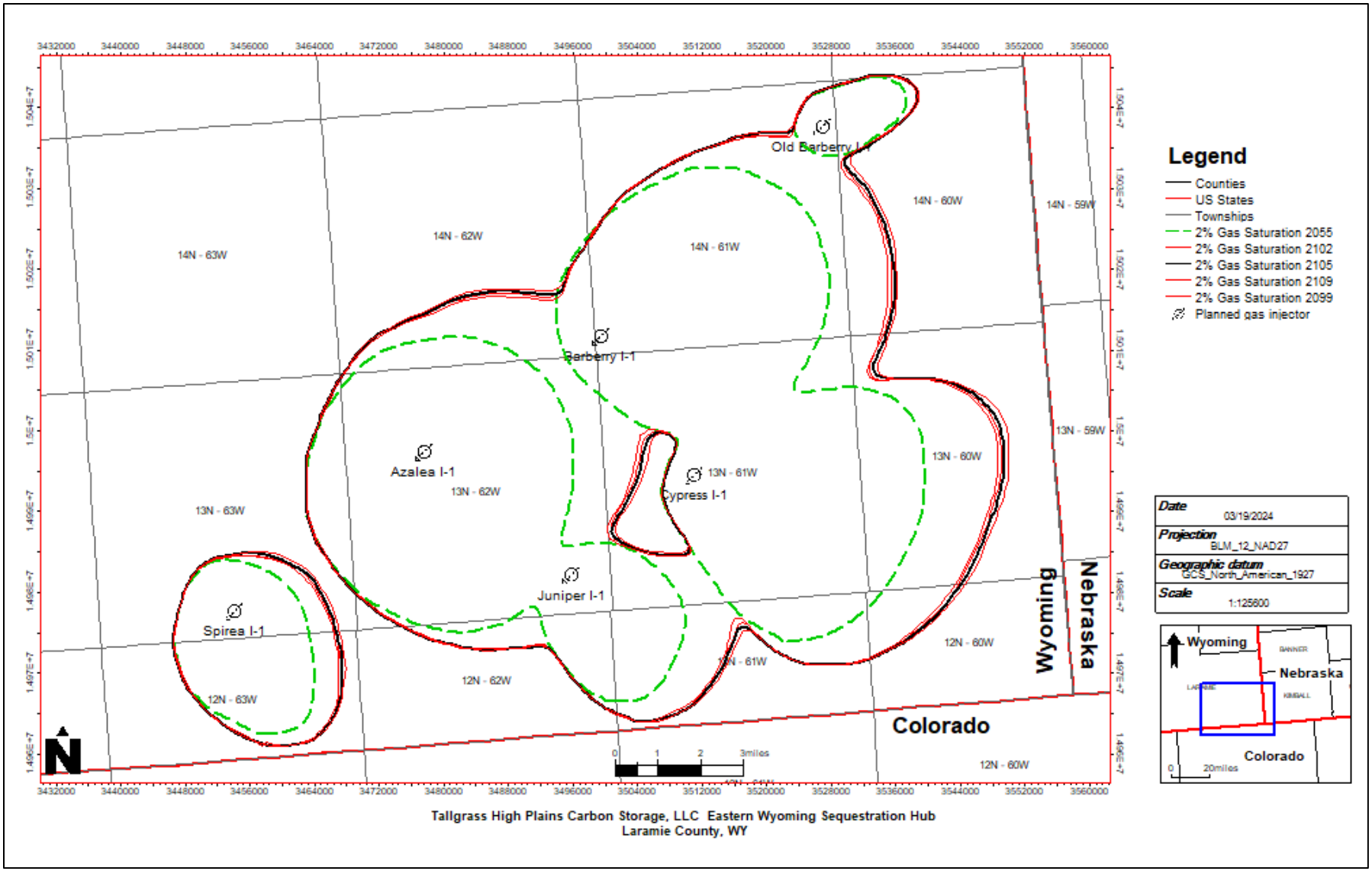



*Figure RTC-8 - Barberry I-1, Cypress I-1, Old Barberry I-1, Spirea I-1, Azalea I-1 (and Juniper I-1) plume stabilization, showing end of injection at year 2055 (green dotted outline) and the final years leading up to cessation of migration in 3-year increments (red and black outlines).*

**SPECIFIC COMMENT 10**

***SC-10 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 24(a)(ii)(M), the predicted rate of CO2 trapping is required.*

***SC-10 Response:***

The Barberry I-1, Cypress I-1, Spirea I-1, Azalea I-1, and Old Barberry I-1 wells collectively begin injection in 2025 and the injection ceases in 2055 (individual injection cessation dates seen in Table RTC-2). Trapping mechanisms have been modeled with all wells (including the Juniper I-1) injecting at the same time. The compositional program used for $CO_2$ injection (CMG-GEM) calculates the $CO_2$ Inventory, which corresponds to the amount of $CO_2$ stored in the reservoir (saline aquifer) under various forms such as: gas, liquid, trapped, super-critical, soluble, aqueous components and minerals trapping mechanism. The default output for the trapping mechanism from the simulator is a plot for the field representing a total amount of $CO_2$ stored in the model and shown in Figure RTC-9. Figures RTC-10 – RTC-15 shows the $CO_2$ inventory mass rate in metric tonne/day for each of the wells calculated as the injection ratio by the $CO_2$ inventory for each of the field trapping mechanism in function of time.

$CO_2$ Trapping Rate = [(well injection / total injection) * field trapping mechanism] / time

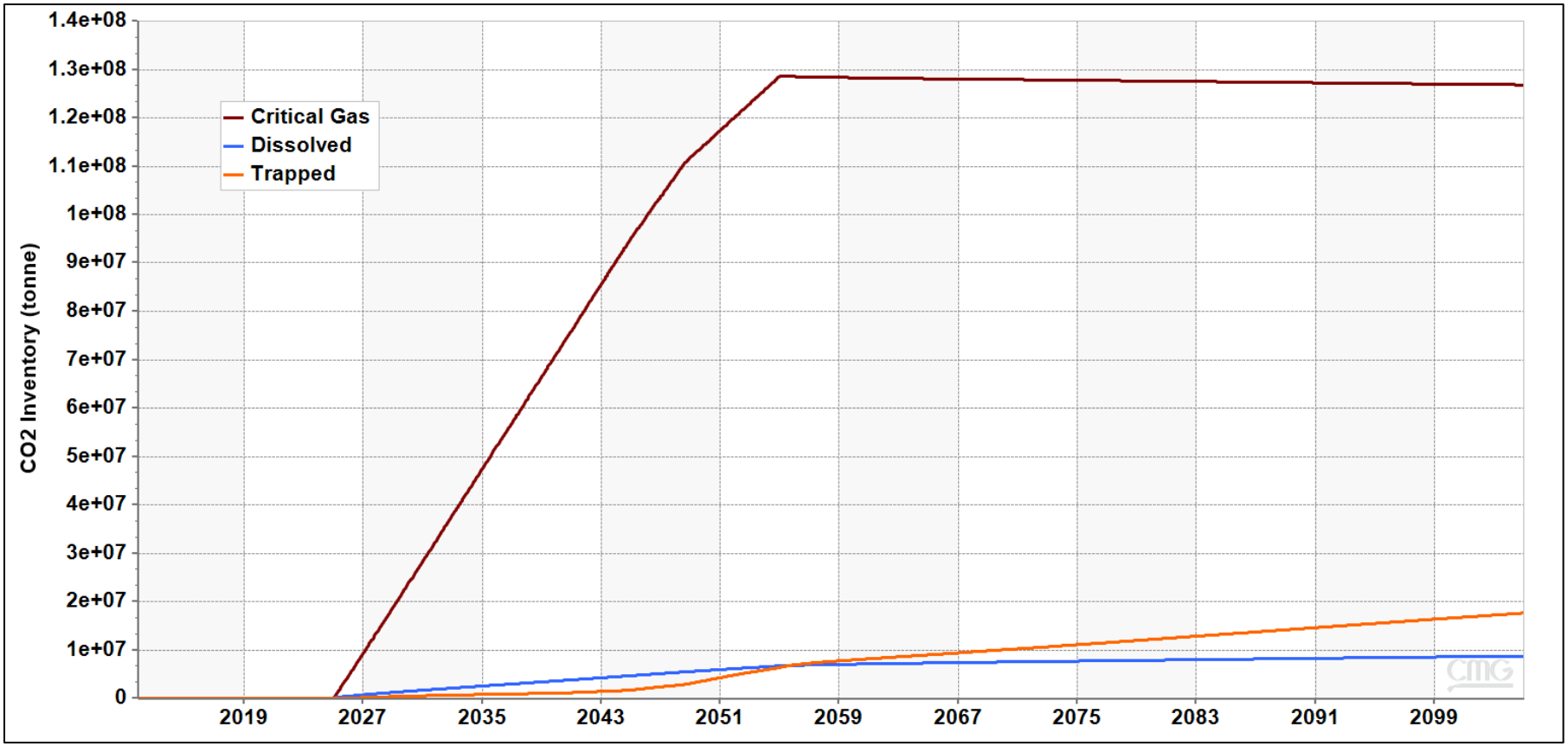



*Figure RTC-9. Field $CO_2$ Inventory – all wells injecting at the same time, this plot is the output from the dynamic reservoir simulator.*

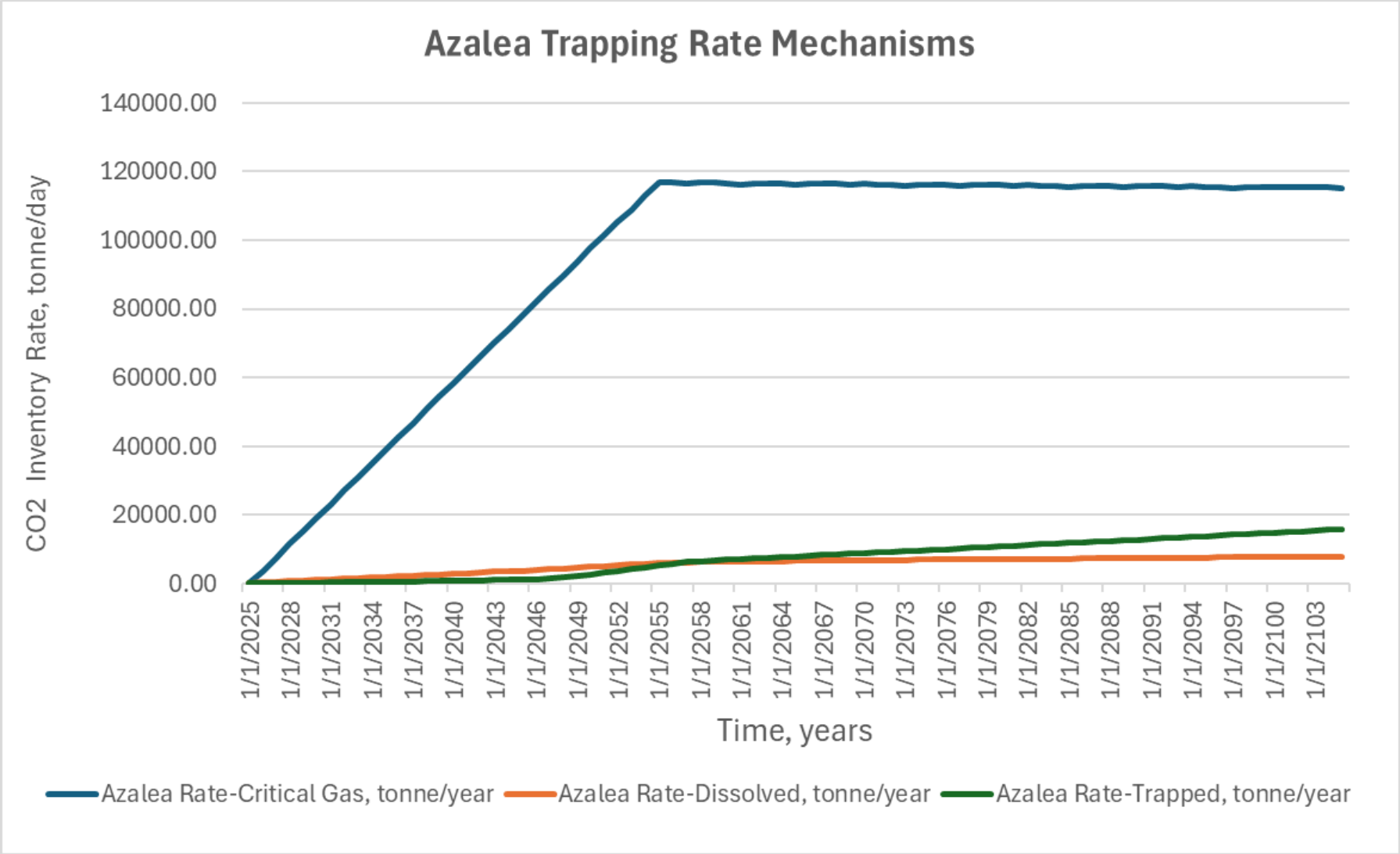



*Figure RTC-10. $CO_2$ trapping mechanism rate (tonne/day) for Azalea I-1.*

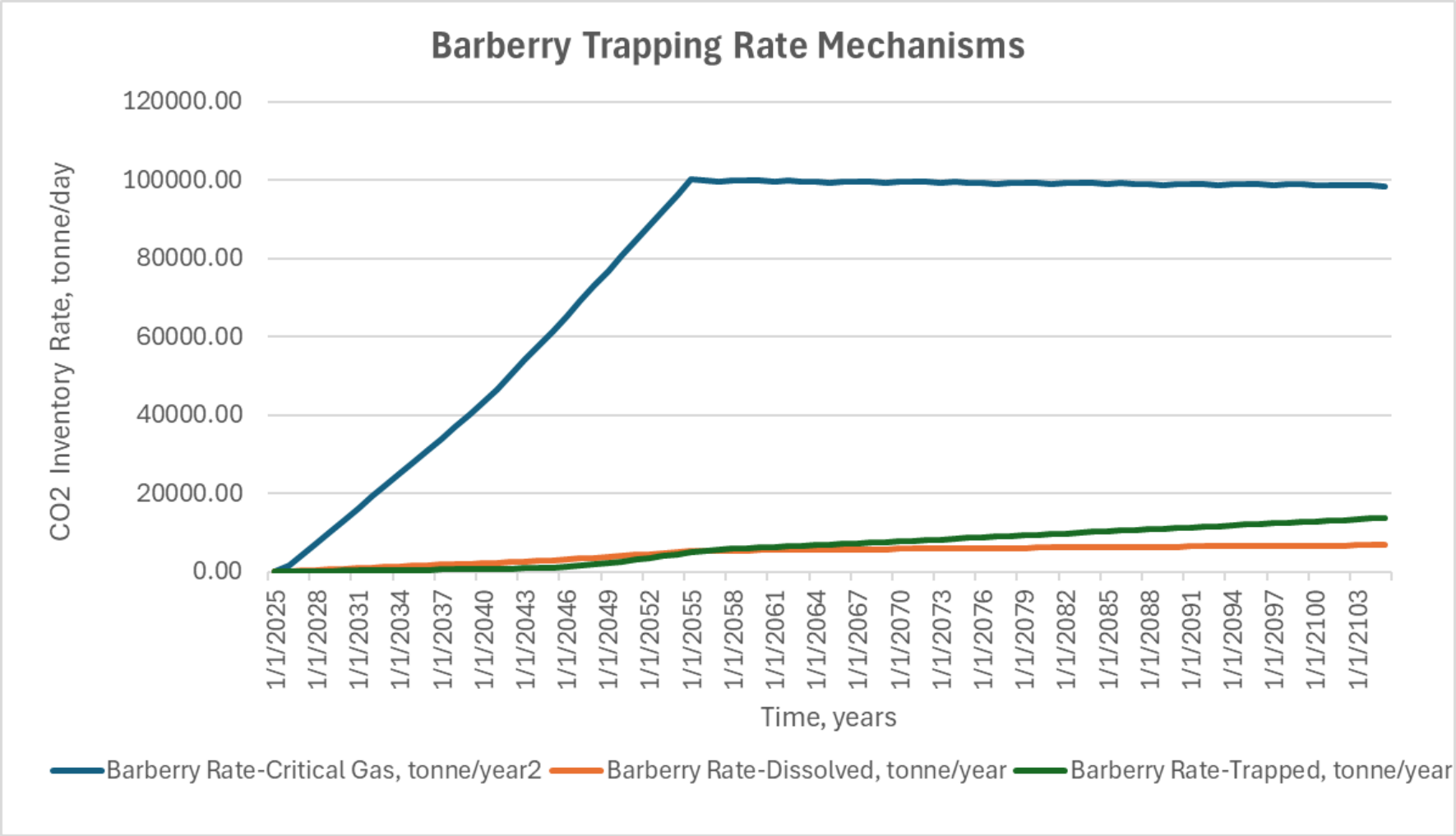



*Figure RTC-11. $CO_2$ trapping mechanism rate (tonne/day) for Barberry I-1.*

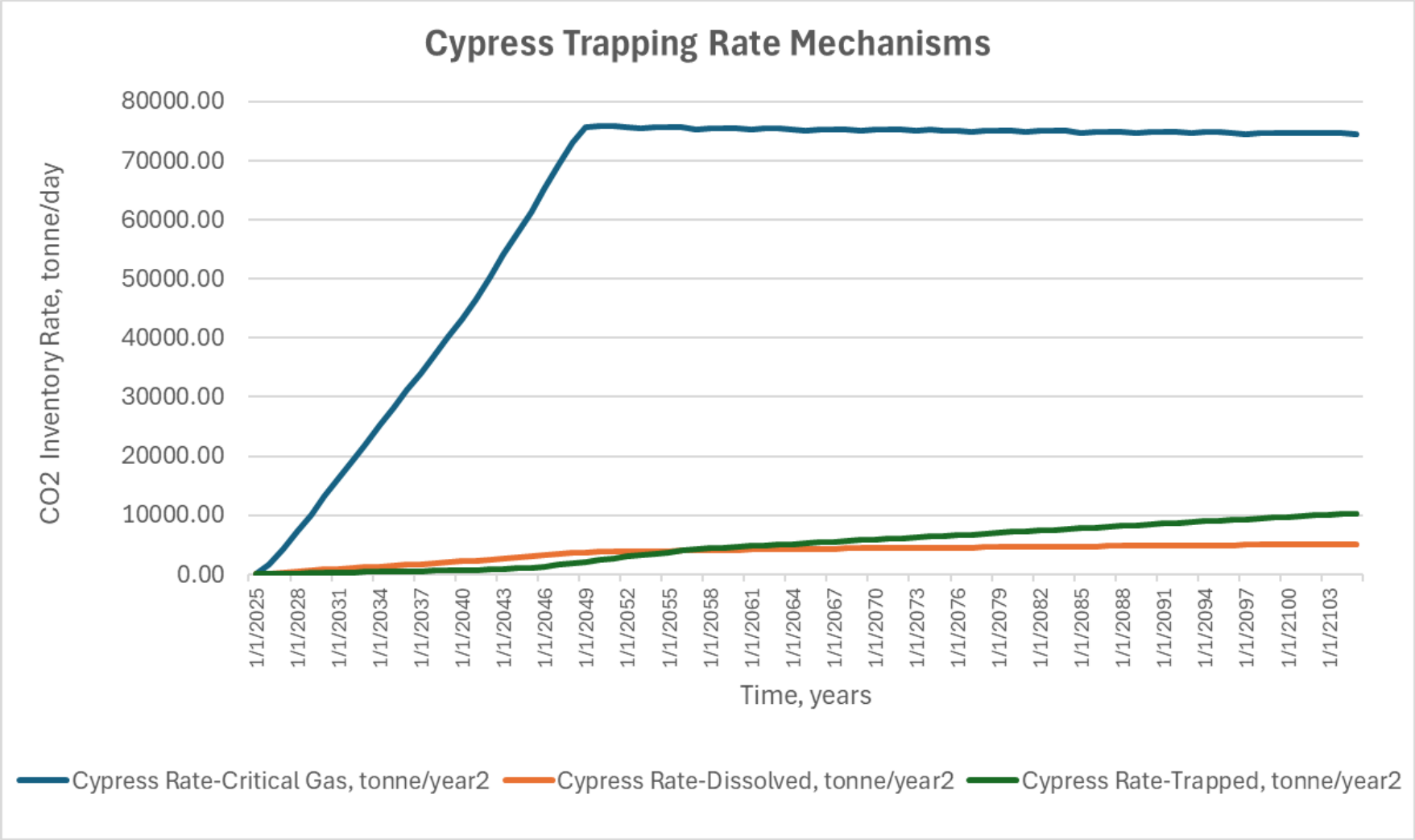



*Figure RTC-12. $CO_2$ trapping mechanism rate (tonne/day) for Cypress I-1.*

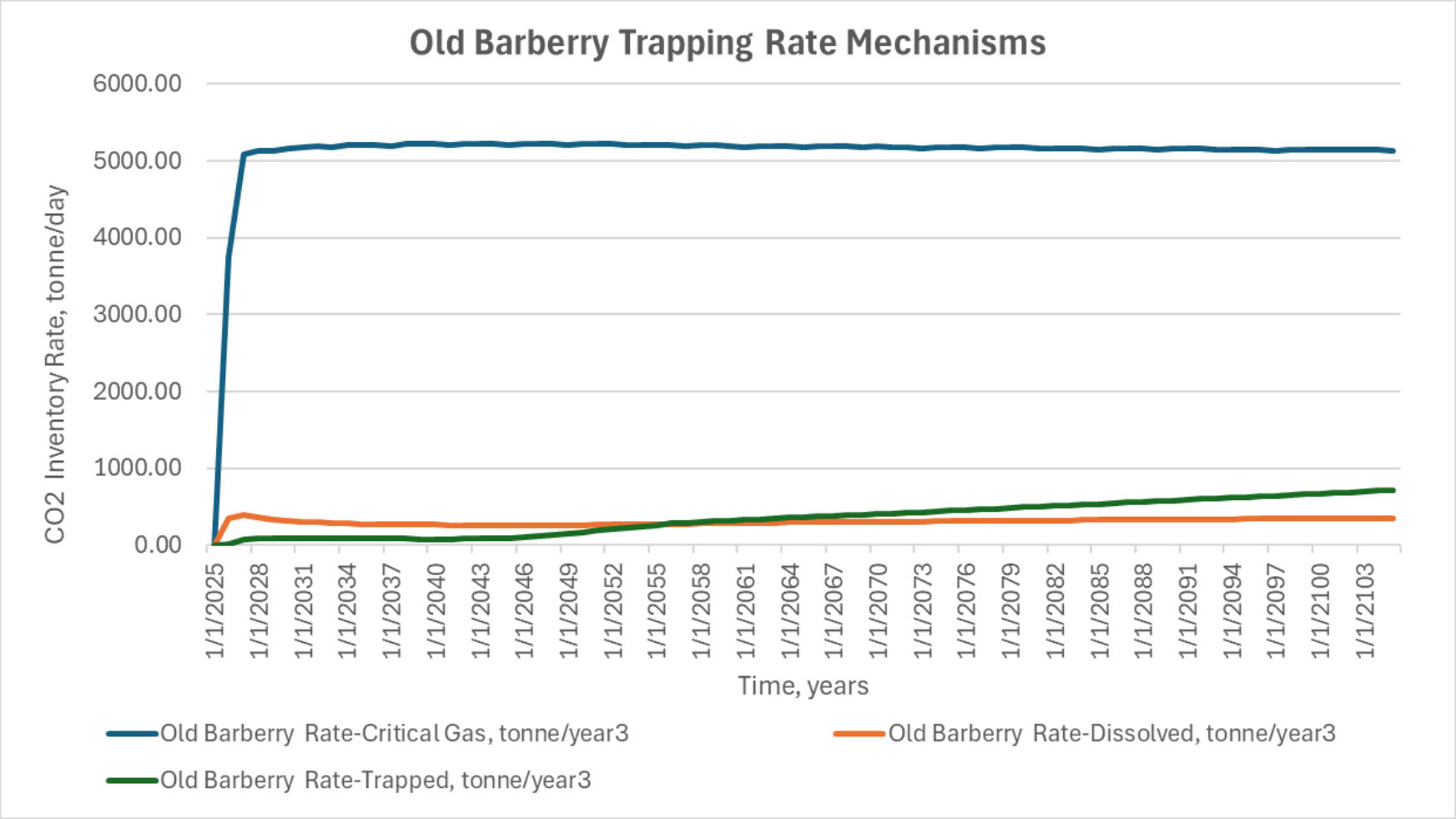



*Figure RTC-13. $CO_2$ trapping mechanism rate (tonne/day) for Old Barberry I-1.*

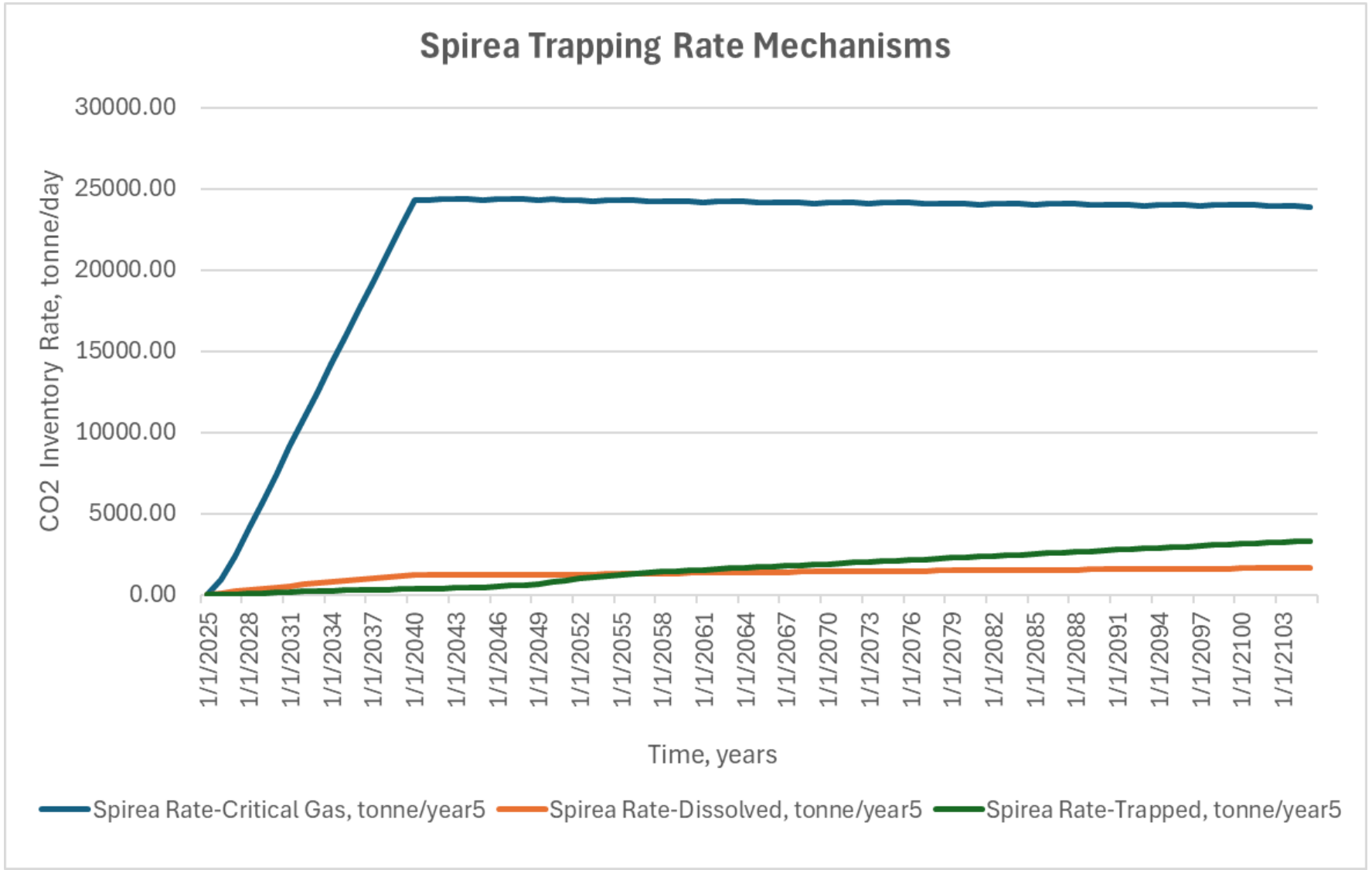



*Figure RTC-14. $CO_2$ trapping mechanism rate (tonne/day) for Spirea I-1.*

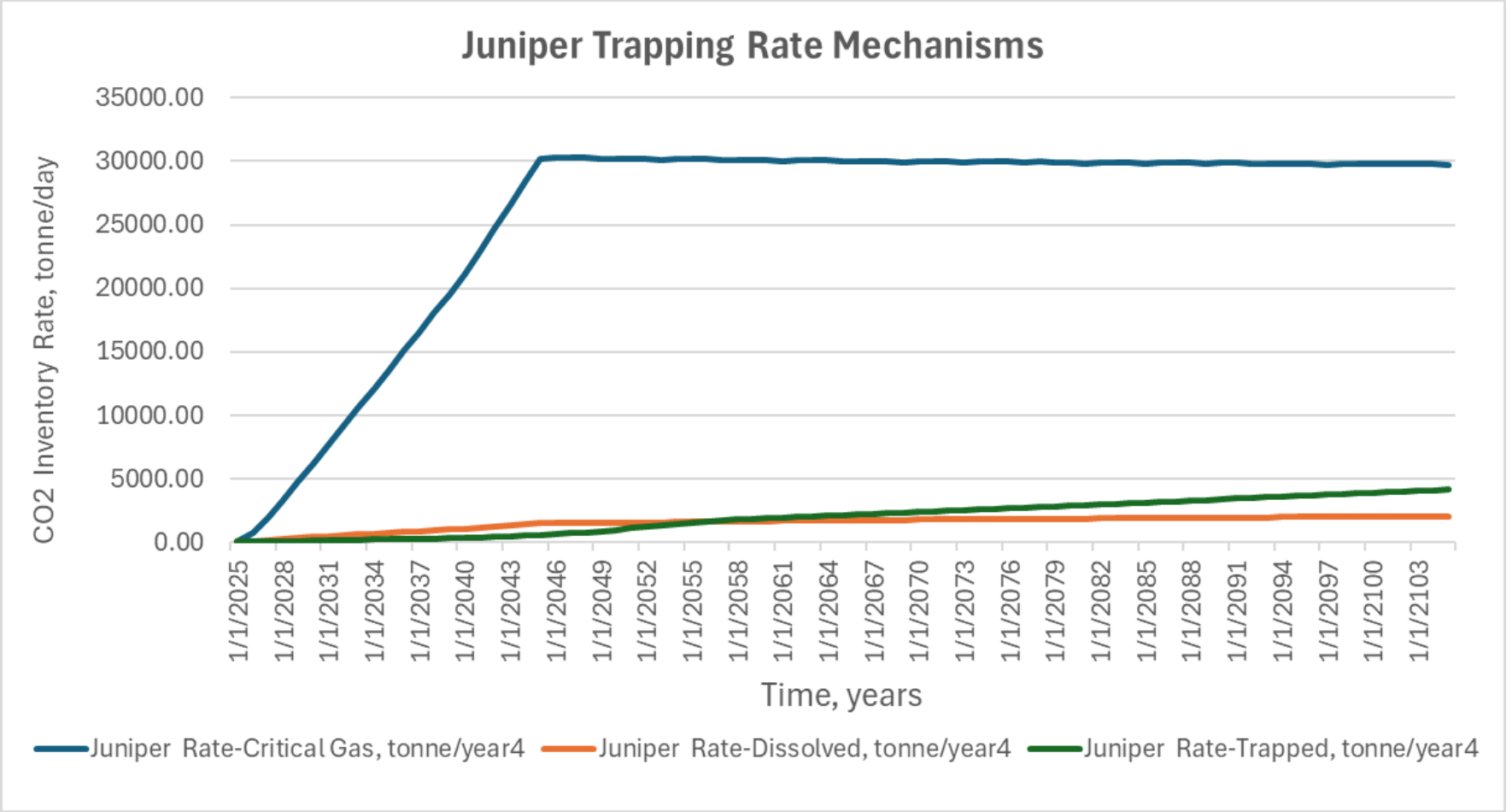



*Figure RTC-15. $CO_2$ trapping mechanism rate (tonne/day) for Juniper I-1.*

**SPECIFIC COMMENT 11**

***SC-11 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 26(a)(ii), financial assurance for each phase of the project is required including monitoring and testing; financial assurance for each phase is required to be reported separately from other financial assurance estimates.*

***SC-11 Response:***

Financial assurance information can be found in the Attachments folder accompanying this document.

**SPECIFIC COMMENT 12**

***SC-12 WYDEQ Comment:***

*In accordance with WWQR, Chapter 24, Section 10(b)(xxxi), a public liability insurance certificate that, in addition to meeting the requirements of W.S. § 35-11-313(f)(ii)(O), demonstrates that the public liability insurance policy meets the requirements of Section 26(l)(i)(B) of this Chapter; identifies each facility by name, address, and EPA Identification Number; and identifies the amounts and types of coverage for each facility is required prior issuance of a Permit to Construct.*

***SC-12 Response:***

A public liability insurance certificate that meets the aforementioned requirements can be found in the Attachments folder accompanying this document.

**SPECIFIC COMMENT 13**

***SC-13 WYDEQ Comment:***

*Section 2.4.1.5 of the permit application states "Note oil saturation > 0 is indicative of oil-based mud invasion." Provide evidence as to how oil saturation in the core taken in the Juniper M-1 can be as high as 46% due to drilling with oil-based mud.*

***SC-13 Response:***

High Plains has taken a second look into the high oil saturation values seen in Table 2.11 in the permit applications and determined they can be attributed to two items: 1. Improper preparation/cleaning of samples and erroneous material balance during the Dean Stark process (for example, salt from the >200k ppm formation fluid was not accounted for) and 2. Under-pressure of the Lyons formation coupled with high permeability leading to increased susceptibility of the core to oil-based mud (OBM) invasion. Additionally, there is no evidence that the oil saturation comes from in situ hydrocarbons in the Lyons formation. The Juniper M-1 wireline log resistivities are around 0.2 ohm-m in the best quality sand sections (~9145'-9180' MD, see "Juniper M-1 TCOM" log in Attachments). Gas shows were not encountered while drilling through the Lyons and no fluorescence or evidence of native oil was observed from drill cuttings within the Lyons section designated on the mud log and mass spec from 9120' to 9180' MD. The Juniper M-1 mud log and mass spectrometry log are located in the Attachments folder

as “Mudlog_Juniper M-1” and “Mass Spec Log_Juniper M-1” respectively. High Plains will also seek to confirm the lack of hydrocarbon presence within the Lyons formation with characterization data from the Juniper I-1.

**SPECIFIC COMMENT 14**

***SC-14 WYDEQ Comment:***

*Section 3.1.2 Supporting Maps of the permit application states “As discussed in Appendix B, the extent of the pressure front at the critical pressure threshold is smaller than the CO2 plume extent, therefore the AoR is determined by the CO2 plume extent.”*

a. *Please clarify how you arrived at this conclusion incorporating evaluations of the AoR (using the EPA approach) that indicate a different methodology (i.e. the risk-based approach) is appropriate.*

***SC-14 Response:***

According to Chapter 24, “Area of Review” is defined as the three-dimensional extent of the carbon dioxide plume, associated pressure front and displaced fluids of the overlying formations and the surface area above the delineated region. By this definition, the AoR would be beyond the modeled domain extent as the pressure signal would travel within the Lyons injection zone to its maximum connected extent (Figure RTC-16).

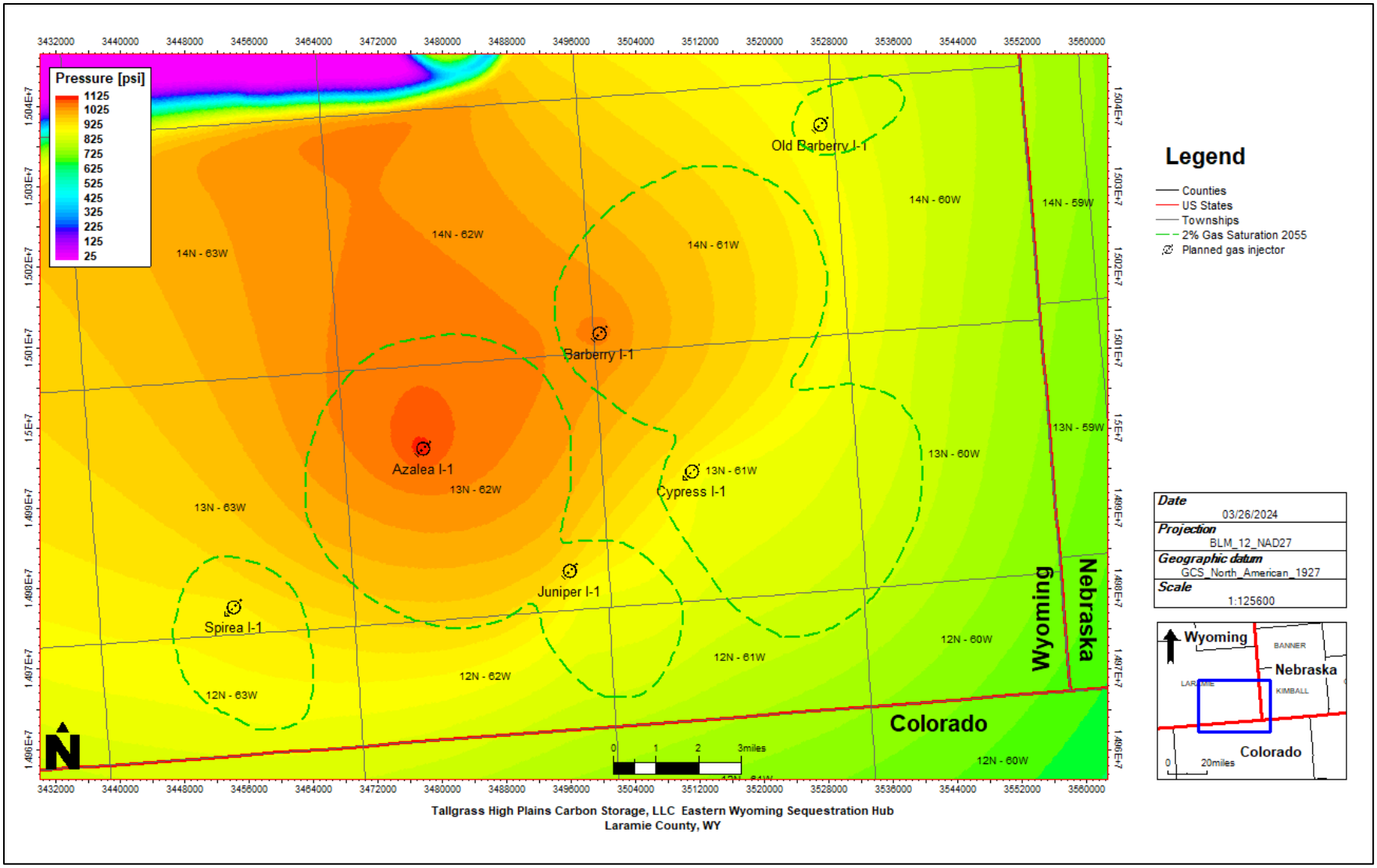



*Figure RTC-16 – Change in Barberry I-1, Cypress I-1, Old Barberry I-1, Spirea I-1, Azalea I-1, Juniper I-1 reservoir pressure representing the time from collective start of injection in year 2025 to end of injection in year 2055.*

The Lyons formation (the injection zone) runs throughout the DJ basin and its extent can be seen in Figure RTC-17 below as depicted in literature.

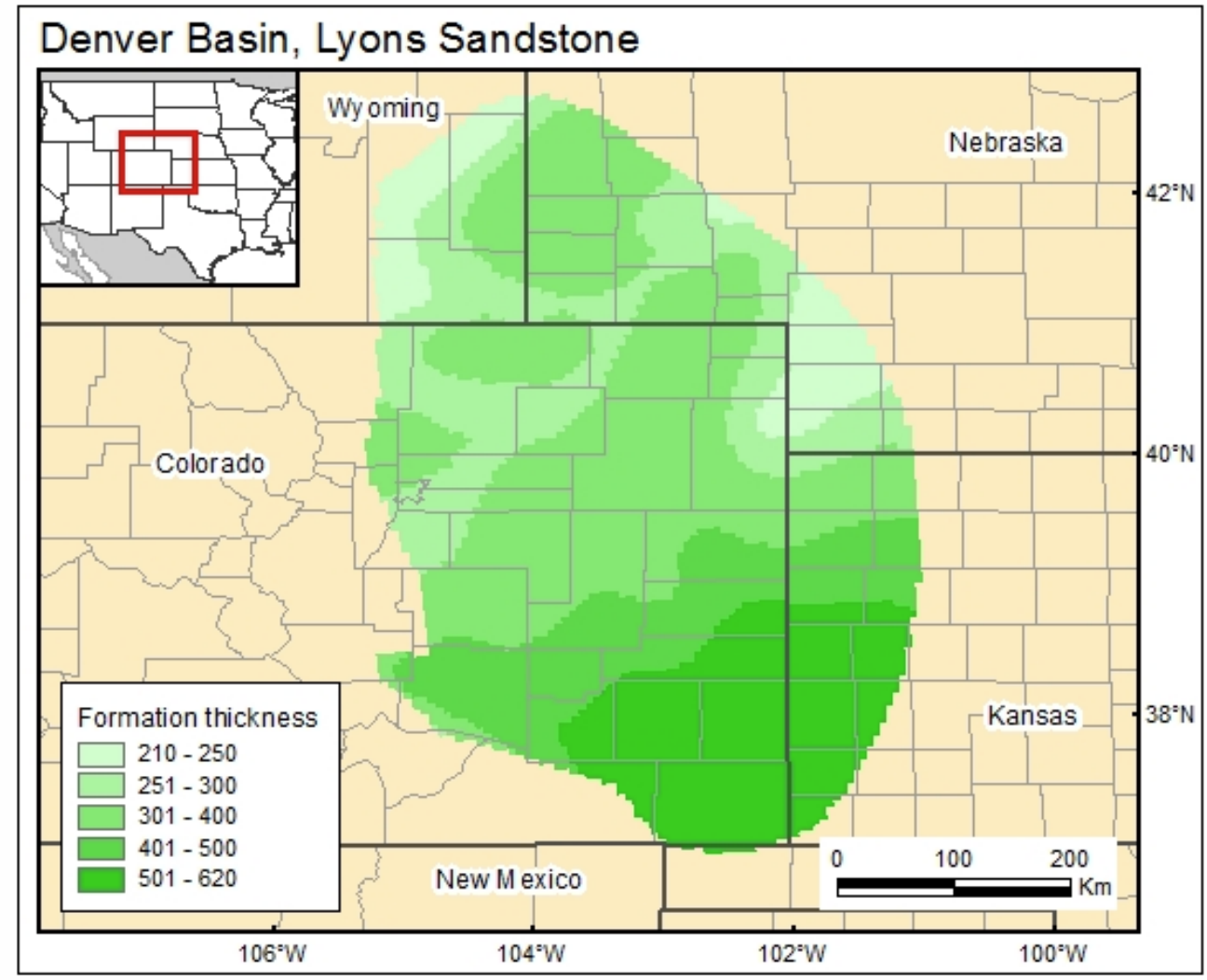



*Figure RTC-17 - Extent of Lyons Sandstone, Denver Basin from Garbarini, G., and Veal, H. K., 1968 and Levandowski, D., Kaley, M., and Smalley, R., 1973.*

Corrective action on an AoR identified by associated pressure front is impractical. Therefore, High Plains proposes utilizing the methodology defined by the EPA Guidance document where AoR is defined by the maximum extent of the $CO_2$ plume, critical pressure increase, or the maximum combination of the two. In this methodology, the pressure state of the injection zone and the lowermost USDW is evaluated to calculate the critical pressure, which is defined as the minimum pressure required to lift the injection zone fluid into the lowermost USDW. The details of the calculation are explained in Section B.8 *Delineation of AoR* and B.9 *Critical-Threshold Pressure-Increase Estimation in Injection Well* of each respective permit. To calculate the extent of the AoR, the maximum increase in the reservoir pressure resulting from the

injection of supercritical $CO_2$ (*Figure RTC-16*) was evaluated at all points within the model domain and compared to the critical pressure calculated in Equation B.7 of each respective permit and shown below. At no point in the model domain is there sufficient hydraulic potential to lift fluid from the injection zone into the Fox Hills (lowermost confirmed USDW).

The methodology for finding critical pressure was sourced from the EPA's Underground Injection Control (UIC) Program Class VI Well Area of Review Evaluation and Corrective Action Guidance, for calculations based on displacing fluid initially present in the borehole in the hydrostatic case. The critical pressure increase is defined as the pressure buildup needed for the hydraulic head of the formation fluid in the injection zone to be equal to or greater than the hydraulic head of the USDW. The base of the USDW is expected to be at 1,265 ft for the Azalea I-1 well, 1,078 ft for the Barberry, 1,056 ft for the Spirea I-1, 1,180 ft for the Old Barberry I-1 well, and 1,040 ft for the Cypress I-1 well as observed on offset logs and at the Juniper M-1. The critical pressure was calculated for the predicted top of the injection interval for each of the wells. The fluid within the USDW was assumed to be freshwater with a salinity of 7,000 mg/L TDS, and a density of 62.8 lb/ft3. The fluid in the injection zone is assumed to be brine with 230,000 mg/L TDS, and a density 76.8 lb/ft3. The hydrostatic gradient for the region is 0.34 psi/ft and a gradient of 0.433 psi/ft is used for the lowermost USDW.

Critical pressure equation (Equation B.7 of each respective permit)

$$\Delta P_c = P_{usdw} + (dz_i - dz_{usdw}) * SG_i * 0.433 \ - P_i$$

$P_{usdw} = Hydrostatic\ Pressure\ at\ the\ base\ USDW\ (psi)$
$dz_i = Depth\ of\ the\ top\ of\ the\ injection\ zone\ (ft)$
$dz_{usdw} = Depth\ of\ the\ base\ of\ the\ USDW\ (ft)$
$SG_i = Specific\ Gravity\ of\ the\ liquid\ in\ the\ injection\ zone$
$P_i = Hydrostatic\ pressure\ at\ the\ top\ of\ the\ injection\ zone\ (psi)$

The critical pressure calculated using the equation above is positive for each of the respective wells, indicating that the reservoir is under pressured relative to the USDW, and that the reservoir pressure in the Lyons formation may be safely increased by each of the respective critical pressure (ΔPc) without risk of generating sufficient hydraulic potential for fluids to migrate from the injection zone to the USDW.

A summary of the inputs and calculations are included in Table RTC-3 below for each of the wells.

**Table RTC-3. Inputs and calculations for critical pressure and maximum pressure per respective injection well.**

| Input | Units | Azalea I-1 | Barberry I-1 | Spirea I-1 | Old Barberry I-1 | Cypress I-1 |
|---|---|---|---|---|---|---|
| Depth to Base of USDW | ft | 1,265 | 1,078 | 1,056 | 1,108 | 1,040 |
| Depth to top of Injection Zone | ft | 9,349 | 8,997 | 9,447 | 8,616 | 8,951 |
| Temp. in USDW | $^oF$ | 90 | 90 | 90 | 90 | 90 |
| Temp. in Injection Zone | $^oF$ | 247 | 261 | 256 | 238 | 255 |
| Salinity in USDW | mg/L | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 |
| Salinity in Injection Zone | mg/L | 230,000 | 230,000 | 230,000 | 230,000 | 230,000 |
| Fluid Density in USDW | $lb/ft^3$ | 62.8 | 62.8 | 62.8 | 62.8 | 62.8 |
| Fluid Density in Injection Zone | $lb/ft^3$ | 76.8 | 76.8 | 76.8 | 76.8 | 76.8 |
| Initial Pressure at Base of USDW | psi | 380 | 323 | 317 | 332 | 312 |
| Initial Pressure at Top of Injection Zone | psi | 3,179 | 3,059 | 3,212 | 2,929 | 3,043 |
| Critical Pressure (ΔPc) Values for each permit | psi | 1,506 | 1,482 | 1,574 | 1,402 | 1,482 |
| Maximum Increase in Reservoir Pressure Modeled – values in permits- | psi | 1,328 | 1,391 | 1,297 | 1,023 | 1,391 |

The maximum increase in reservoir pressure modeled is between 1,023 psi for Old Barberry I-1 well and 1,391 psi for Barberry I-1 and Cypress I-1 wells (Table RTC-3). At no point in the model domain is the increase in reservoir pressure sufficient to exceed the critical pressure. The AoR is defined as the extent of the plume where the modeled $CO_2$ saturation is greater than 2%.

However, in addition to the proposed lowermost USDW, there are other permeable zones between the injection zone and the Fox Hills that can accept fluids, should fluids escape the injection zone. The lowermost permeable sand above the injection zone is the Sundance formation. Similarly, the pressure state of Sundance and Lyons were compared to calculate critical threshold pressure. The Sundance is under-pressured with respect to Lyons. In other words, if there was an open conduit between the two formations, fluids from Lyons formation would be able to freely escape into the Sundance without any additional manmade pressure introduced. As can be seen in Figures RTC-18 and RTC-19, the salinity of the formation fluids in Sundance and Lyons are different by an order of magnitude, indicating regional isolation between the two formations. High Plains does not anticipate formation fluids escaping from Lyons to Sundance and proposes the maximum plume extent as the extent of AoR.

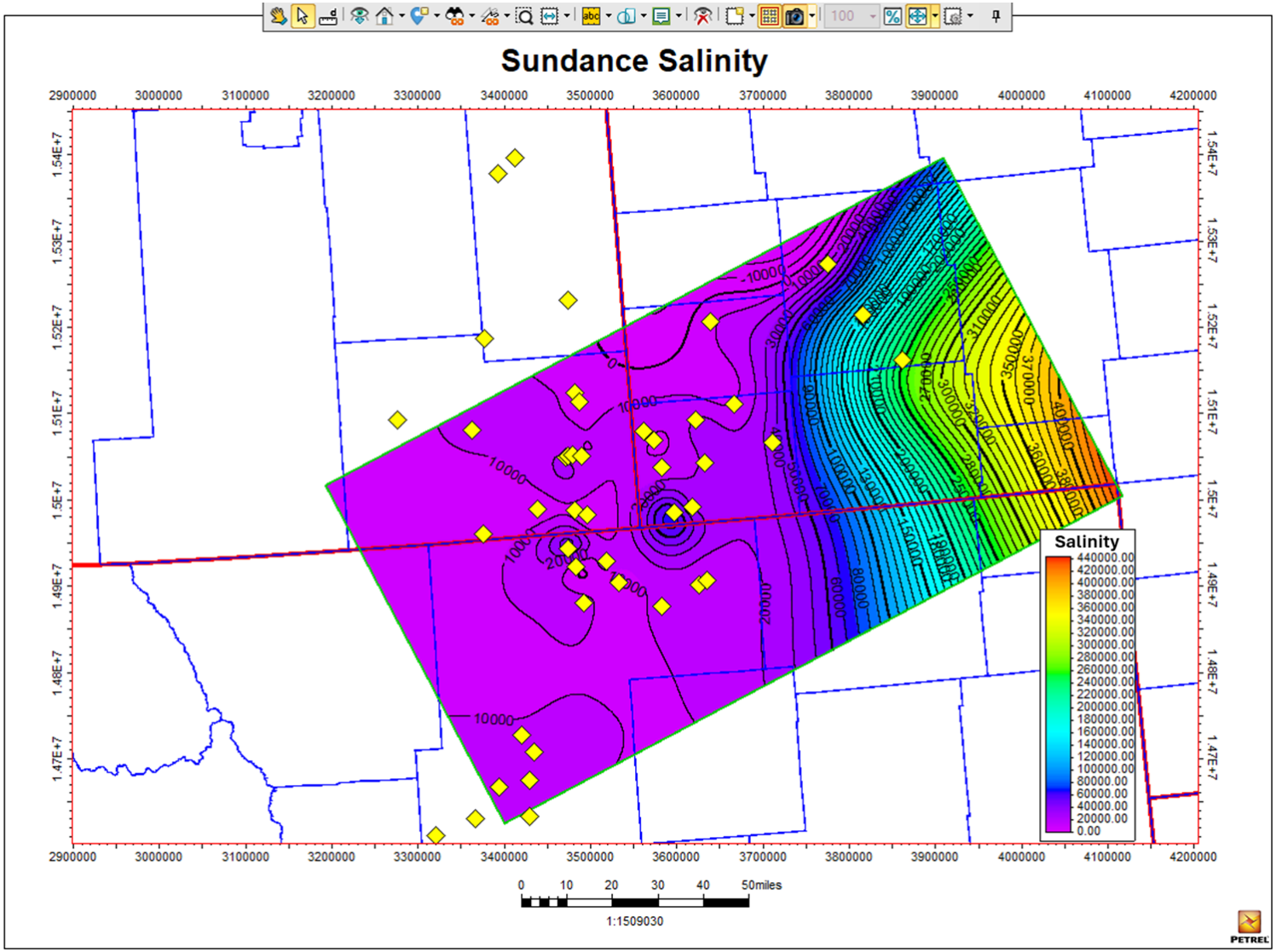



*Figure RTC-18. Sundance formation salinity.*

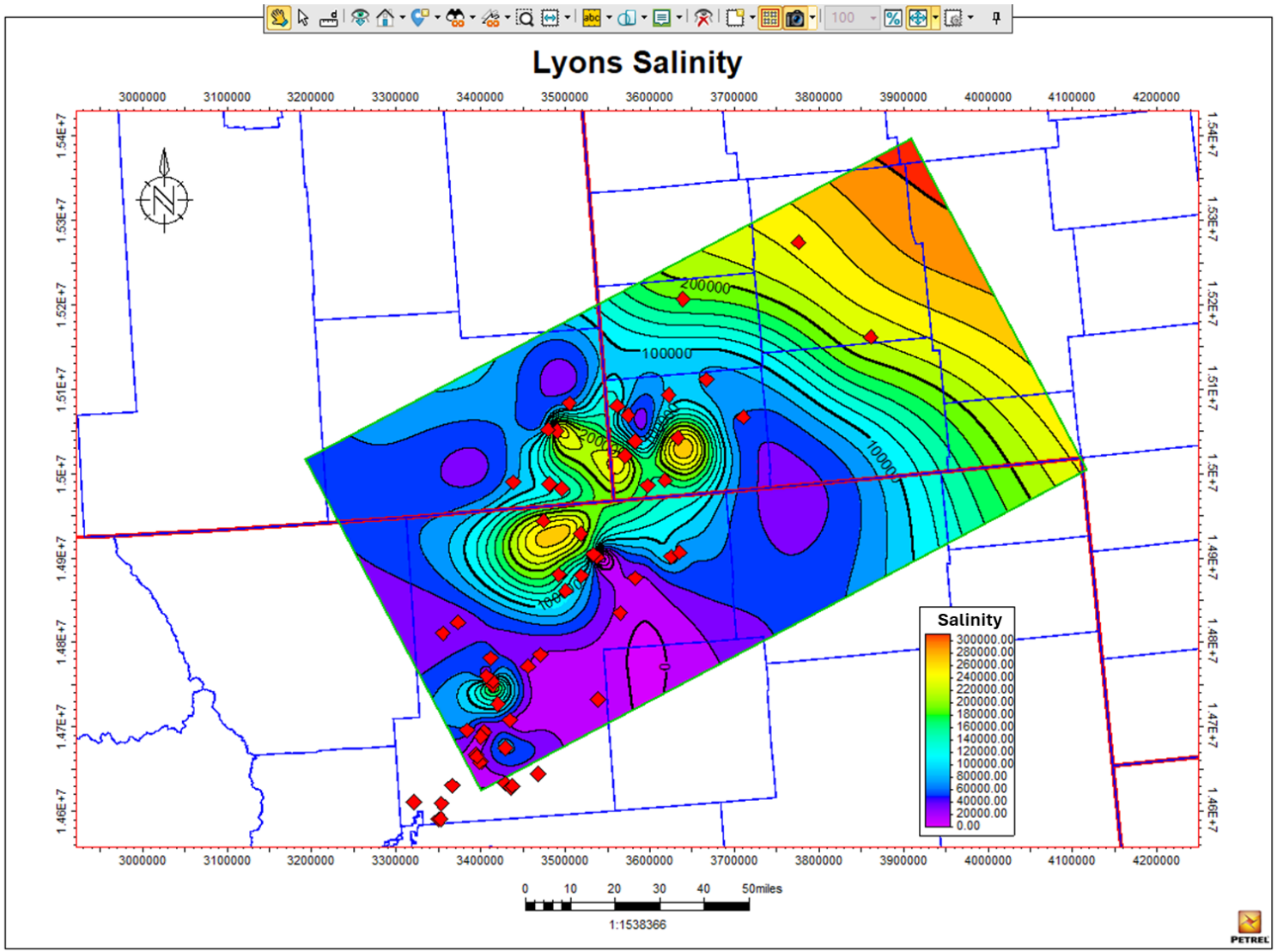



*Figure RTC-19. Lyons formation salinity.*

**SPECIFIC COMMENT 15**

***SC-15 WYDEQ Comment:***

*Section 3.6 Reevaluation of AoR and Corrective Action Plan of the permit application states "A report will be generated to include the data and results demonstrating that no changes are necessary. If material changes have occurred, then the conceptual model will be updated with the new data and a report will be generated and sent to WYDEQ. This report will include comparisons between the previous simulation and the updated version, details of potential corrective action and a current status of the corrective action.*

a. *If any change to the AoR has occurred, the conceptual model must be updated and a report generated which must be submitted with the next scheduled semiannual report. If a report that demonstrates no changes are necessary is submitted, it must also be submitted with the next scheduled semiannual report for WDEQ review and approval. Changes to the AoR and corrective action plan will require a permit modification.*

***SC-15 Response:***

High Plains has reconfigured the language in Section 3.6 Reevaluation of AoR and Corrective Action Plan of the permit application to read:

"If the new monitoring and operating data reviewed is consistent with the most recent modeling assumptions and is not expected to materially influence the modeled extent of plume and pressure front movement, no reevaluation of the AoR will be undertaken. A report will be generated and submitted with the next scheduled semiannual report for WDEQ review and approval. The report will include the data and results demonstrating that no changes are necessary. If material changes have occurred, then the conceptual model will be updated with the new data and a report will be submitted with the next scheduled semiannual report for WDEQ review and approval. This report will include comparisons between the previous simulation and the updated version, details of potential corrective action and a current status of the corrective action. High Plains will then prepare for a permit modification where the AoR and Corrective Action Plan will be updated to reflect the revised AoR, along with other related project plans, as needed."

**SPECIFIC COMMENT 16**

***SC-16 WYDEQ Comment:***

*Table 4.3 Actions necessary to determine cause of events and appropriate emergency response of the permit application states "If a seismic event occurs within the AoR of the injection well, of a magnitude greater than 3.0, review the pressure and volume injection history to determine if there is a correlation with the injection activities. Confirm that the well has maintained mechanical integrity and whether a loss of CO2 containment has occurred."*

a. *The WDEQ requires quarterly reporting of all seismic events greater than 1.0. At this time, the WDEQ cannot support a minimum magnitude reporting threshold of 3.0. Final*

*minimum magnitude reporting threshold numbers cannot be established until further data is collected from the well area.*

***SC-16 Response:***

High Plains has adjusted the minimum reporting threshold to a seismic event greater than 1.0 at this time as seen in Table RTC-4. High Plains will continue to follow this guidance until WDEQ advises otherwise.

**Table RTC-4. Actions necessary to determine cause of events and appropriate emergency response for induced seismicity (*Barberry I-1, Azalea I-1, Old Barberry I-1, Spirea I-1, Cypress I-1*).**

| Emergency Action | Determine Cause and Emergency Response |
|---|---|
| Induced seismic event | • Identify the location, depth, and magnitude of the event.<br>• If a seismic event occurs within the AoR of the injection well, of a magnitude greater than 1.0, review the pressure and volume injection history to determine if there is a correlation with the injection activities. Confirm that the well has maintained mechanical integrity and whether a loss of $CO_2$ containment has occurred.<br>• Remediate as necessary in coordination with the Administrator.<br>• Include details of event in quarterly report to WDEQ. |

**SPECIFIC COMMENT 17**

***SC-17 WYDEQ Comment:***

*Section 4.4.2 Proposed Monitoring Well Casing and Cementing Programs of the permit application states "The well will be drilled through the Sundance and will penetrate the top of the Chugwater," whereas Section 4.5.2.1 Pre-plugging Procedures 2. Determination of bottomhole reservoir pressure states "The well is not expected to be perforated or open to any formation and the total depth at drilling and completion was to be above the containment layers for the Lyons sequestration reservoir."*

*a. These statements both refer to the monitoring wells and contradict each other. Please clarify if the Chugwater or Goose Egg will be penetrated by the monitoring well(s).*
*b. Monitor wells cannot penetrate the upper confining zone as drilling operations may compromise the integrity of the confining zone.*

***SC-17 Response:***

Monitoring well designs will be proposed to WDEQ pending results from each respective injection well characterization program following the Permit to Construct. One of the main objectives for the monitoring program is to safely characterize, protect and monitor the USDWs. The Sundance formation is an aquifer that is located directly above the Chugwater and Goose Egg primary confining units. During the injection well characterization program, High Plains plans to collect water samples from the Sundance to confirm its salinity. Additional tests

will be run to identify other key attributes of the Sundance such as formation thickness, mineralogy and porosity. Once interpretations are made, High Plains will modify the monitoring well designs.

**SPECIFIC COMMENT 18**

***SC-18 WYDEQ Comment:***

*Section 4.6.3 Groundwater and Soil Gas Monitoring of the permit application states "High Plains does not plan to monitor soil gas at this time as monitoring efforts in the first permeable layer above the confining zone and shallow groundwater sampling will identify leaks before a soil gas survey would."*

*a. Pursuant to WWQR Chapter 24 Section 20(b)(ix), soil gas monitoring is required. Please provide a soil gas monitoring plan.*

***SC-18 Response:***

Pursuant to discussions with WDEQ, High Plains emphasizes that they will employ soil gas monitoring as required in the Chapter 24 regulations.

**Table RTC-5 —Baseline (pre-injection), operational, and post-operational soil gas monitoring (Barberry I-1, Azalea I-1, Spirea I-1, Old Barberry I-1, Cypress I-1).**

| Monitoring Type | Baseline (Pre-injection) | Operational | Post-Operational |
|---|---|---|---|
| **Soil Monitoring** | | | |
| Soil Gas Monitoring | Duration: 1 year<br>Frequency: Semi-Annual | Duration: During injection operations<br>Frequency: Semi-Annual | Duration: Until approved to cease monitoring<br>Frequency: Annual/ other frequency requested by WDEQ |

**SPECIFIC COMMENT 19**

***SC-19 WYDEQ Comment:***

*Section 2.3.6 Fluid Samples of the permit application states "Based on the narrative of the well operations prior to and during sampling, it is not reasonable or possible to claim that water samples obtained are truly from and representative of the Lyons Formation." Section 2.3.6 (PDF page 69) goes on to state "A review of the daily drilling and completion reports shows there is a possibility that the Lyons Formation water sample collected could be contaminated from brine present in the wellbore at the time of sampling. High Plains will collect additional fluid samples in the Lyons Formation in the Barberry I-1 prior to injection."*

*a. Tallgrass will also need to collect water samples from the Sundance Formation, Hygiene Sandstone Member of the Pierre Shale, and the following shallow USDWs:*
   *i. Quaternary alluvial and terrace deposits*
   *ii. "High Plains Regional Aquifer System" or "Tertiary Aquifer System"*

*iii. Ogallala, Arikaree, and White River formations*
*iv. Lance and Fox Hills formations*

***SC-19 Response:***

High Plains has amended the Barberry I-1, Azalea I-1, Old Barberry I-1, Spirea I-1, Cypress I-1 fluid sampling plans to include sample collection within the Sundance Formation, the Hygiene member of the Pierre shale and the requested shallow USDWs, as listed below.

**Deep Formations**

Method: Wireline MDT (or industry equivalent) tool run in injection well

- Hygiene
- Sundance
- Lyons

**Shallow USDWs**

Method: Direct sample from three shallow groundwater wells on injection well padsite

- Alluvium and Terrace deposits near surface
- Ogallala, Arikaree and White River regional aquifers (High Plains Regional Aquifer System or Tertiary Aquifer System)
- Lance and Fox Hills deposits

**SPECIFIC COMMENT 20**

***SC-20 WYDEQ Comment:***

*Per Specific Comment 22, Tallgrass shall submit their water sampling plan(s) to the WDEQ for review and approval prior to collecting any samples, to ensure such samples will be satisfactory to the WDEQ.*

***SC-20 Response:***

High Plains plans to sample water from the Barberry I-1, Azalea I-1, Old Barberry I-1, Spirea I-1, and Cypress I-1 injection sites as described in Specific Comment 19. Per §24.22(b) and as mentioned in the respective Class VI permit applications Section *4.3.13 Reporting and Notice Requirements*, High Plains will notify WDEQ, in writing, of planned sampling activities 30 days in advance.

**SPECIFIC COMMENT 21**

***SC-21 WYDEQ Comment:***

*Tallgrass shall submit final plans for water sampling, monitoring, completions, injection and monitor well plugging, internal and external mechanical integrity testing, and any other well*

*operation procedures to the WDEQ for review and approval prior to performing any of these activities.*

***SC-21 Response:***
High Plains will submit final plans to WDEQ for the requested activities, in writing, no less than 30 days prior to the event in accordance with §24.22 and as mentioned in the respective Class VI permit applications section *4.3.13 Reporting and Notice Requirements*.

## ADDITIONAL BARBERRY I-1, AZALEA I-1, OLD BARBERRY I-1, SPIREA I-1, AND CYPRESS I-1 PERMIT UPDATES AND PROPOSED CHANGES

The following updates will also be made to the Barberry I-1, Azalea I-1, Old Barberry I-1, Spirea I-1, and Cypress I-1 applications.

**Step Rate Test**
High Plains has decided to not include step-rate tests in the formation testing program. Fracture pressure will be determined using the SLB MDT tool, or industry equivalent, and sonic logs as outlined in Specific Comment 5 and Appendix E of each respective permit application. Further formation pressure testing will be conducted with pressure fall-off tests as detailed in Specific Comment 5 and Section *4.3.1.1 Injection Well Integrity Tests* of each respective permit application.

**Injection Well 130' Rathole Justification**
High Plains proposes that the injection wellbores extend 130 ft into the Satanka formation, which makes up a portion of the 250+ ft thick total lower confining unit that underlies the Lyons formation injection zone. The 130 ft of rat hole is required to safely run wireline tools downhole in order to satisfy WDEQ's requirement of characterizing the entirety of the injection zone prior to injection. This extra hole will also provide space needed for future in-zone wireline monitoring operations such as dip-in fiber. The following information demonstrates that once the wells are drilled, High Plains anticipates ~160 ft of the lower confining unit to remain undisturbed between the wellbore and the next deepest potential permeable zone, the Amazon formation.

The Satanka formation was described in detail as a high-quality lower confining zone in *Section 2.4.2.7 -Lower Confining Zone* in the original Class VI permit applications. High Plains is proposing the Wolfcamp formation as a secondary seal that is stratigraphically beneath the Satanka. Thus, the entire lower confining unit refers to the top of the Satanka through the bottom of the Wolfcamp formation. The total thickness of the combined bottom seal units across the AoR is expected to be an average of 290 ft thick. The thickness maps, with the proposed AoR, for both the Satanka and the Wolfcamp formations are shown below in Figures RTC-20 and RTC-21. Table RTC-6 below shows the expected Satanka, Wolfcamp, and total underlying seal thicknesses at each injection well location.

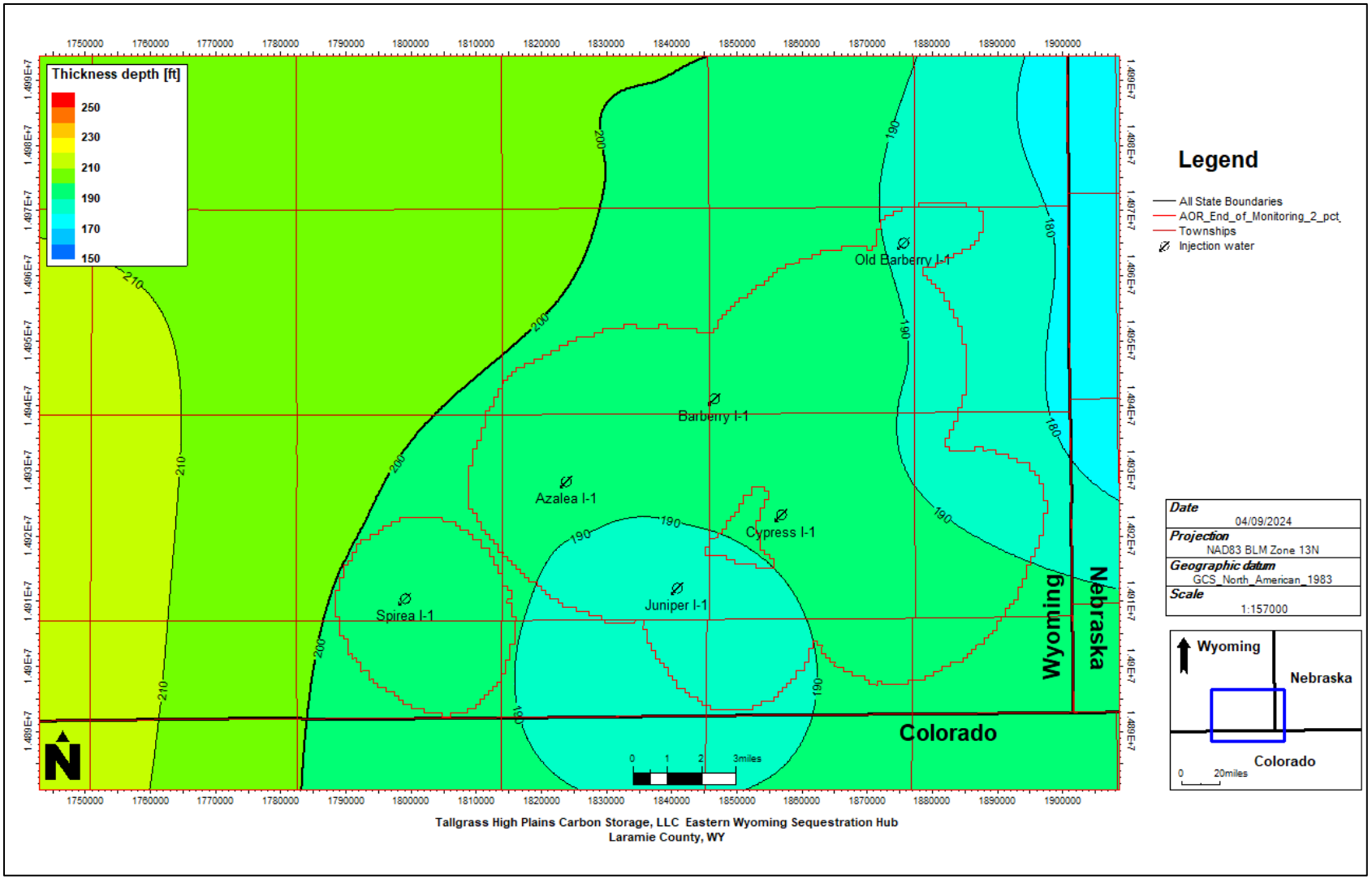



*Figure RTC-20. Satanka thickness map.*

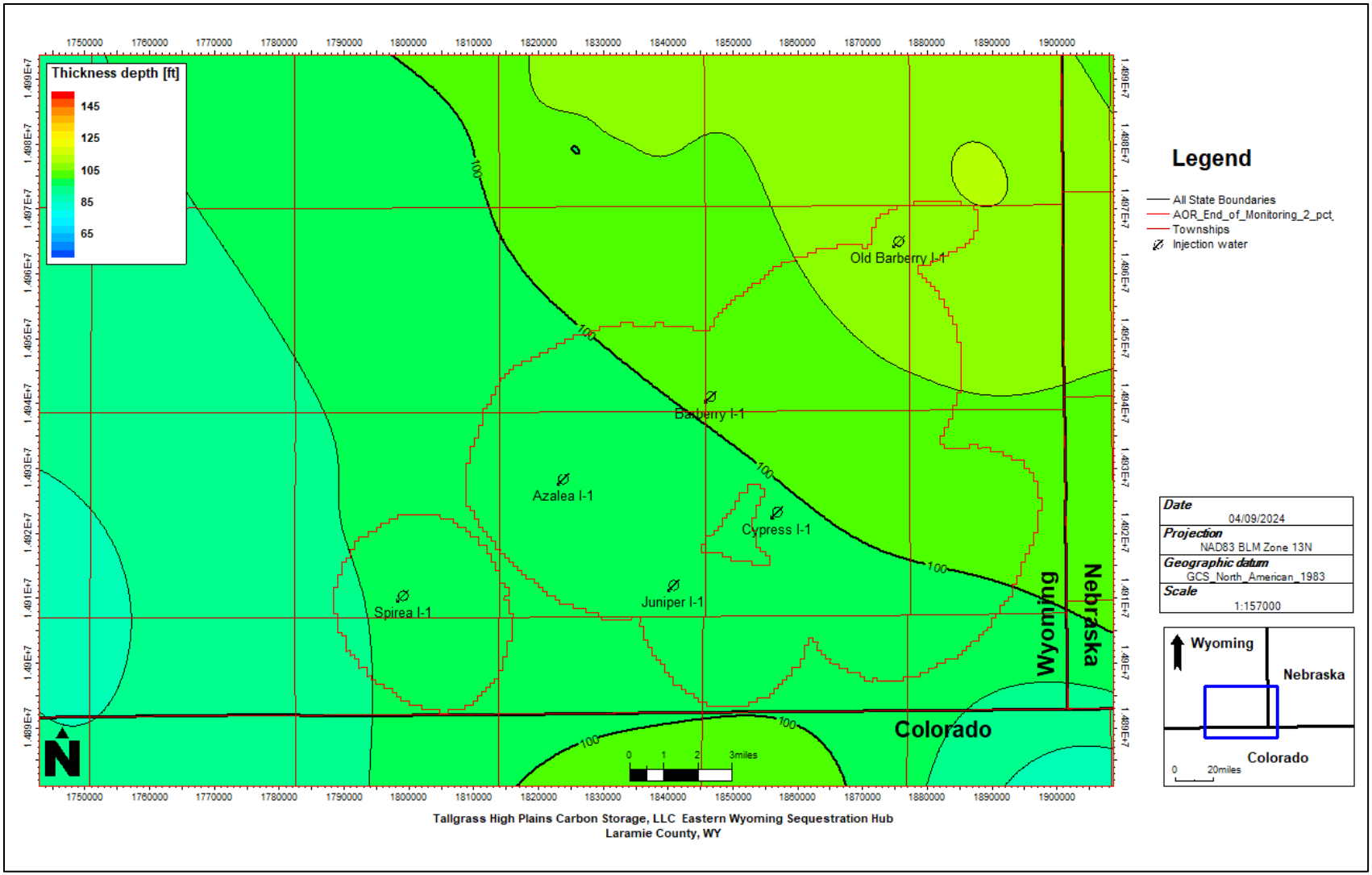



*Figure RTC-21. Wolfcamp thickness map.*

**Table RTC-6. Lower confining zone thicknesses.**

| Projected Underlying Seal Thicknesses (ft) | | | |
|---|---|---|---|
| **Well** | **Satanka** | **Wolfcamp** | **Total** |
| Azalea I-1 | 192 | 98 | 290 |
| Barberry I-1 | 192 | 100 | 292 |
| Cypress I-1 | 191 | 99 | 290 |
| Old Barberry I-1 | 189 | 108 | 297 |
| Spirea I-1 | 196 | 96 | 292 |

The Wolfcamp lithology is anticipated to consist primarily of dolomitized carbonate marlstone, red siltstone, and anhydrite evaporite facies as documented in literature (Montgomery et al. 1998, Garfield et. Al 1988) and as was confirmed in the Juniper M-1 characterization well data. The depositional environment is a restricted back ramp to barrier shoal complex (Garfield et al. 1988). Average porosity for the Wolfcamp is 1-2% (Figure RTC-22) and permeability is projected to average <.01 mD, indicating tight rock conditions for a suitable seal.

No core samples were taken across the Wolfcamp in the Juniper M-1; however, mineralogy averages across the Wolfcamp were petrophysically derived from a full suite of log data, including the Lithoscanner tool (Table RTC-7).

**Table RTC-7 – Wolfcamp Minerology Assumptions within the AoR (all values based on petrophysical analysis).**

| Sample Volume | Percent (%) |
|---|---|
| Anhydrite | 61.5 |
| Dolomite | 19.5 |
| Quartz/SS | 8.5 |
| Clay | 3.9 |
| Calcite | 3.8 |
| Porosity | 2.8 |
| Total Volume | 100 |

The fracture gradient for the Wolfcamp averages 0.56 psi/ft based on dipole sonic log data (Anisotropic Strain – Max/min horizontal stress gradient). This is greater than the calculated fracture gradient for the Lyons (0.47 psi/ft) and the Satanka (0.53 psi/ft). High Plains intends to inject at 90% or less of the Lyons fracture gradient, so the risk of mechanical failure of the Wolfcamp is very low.

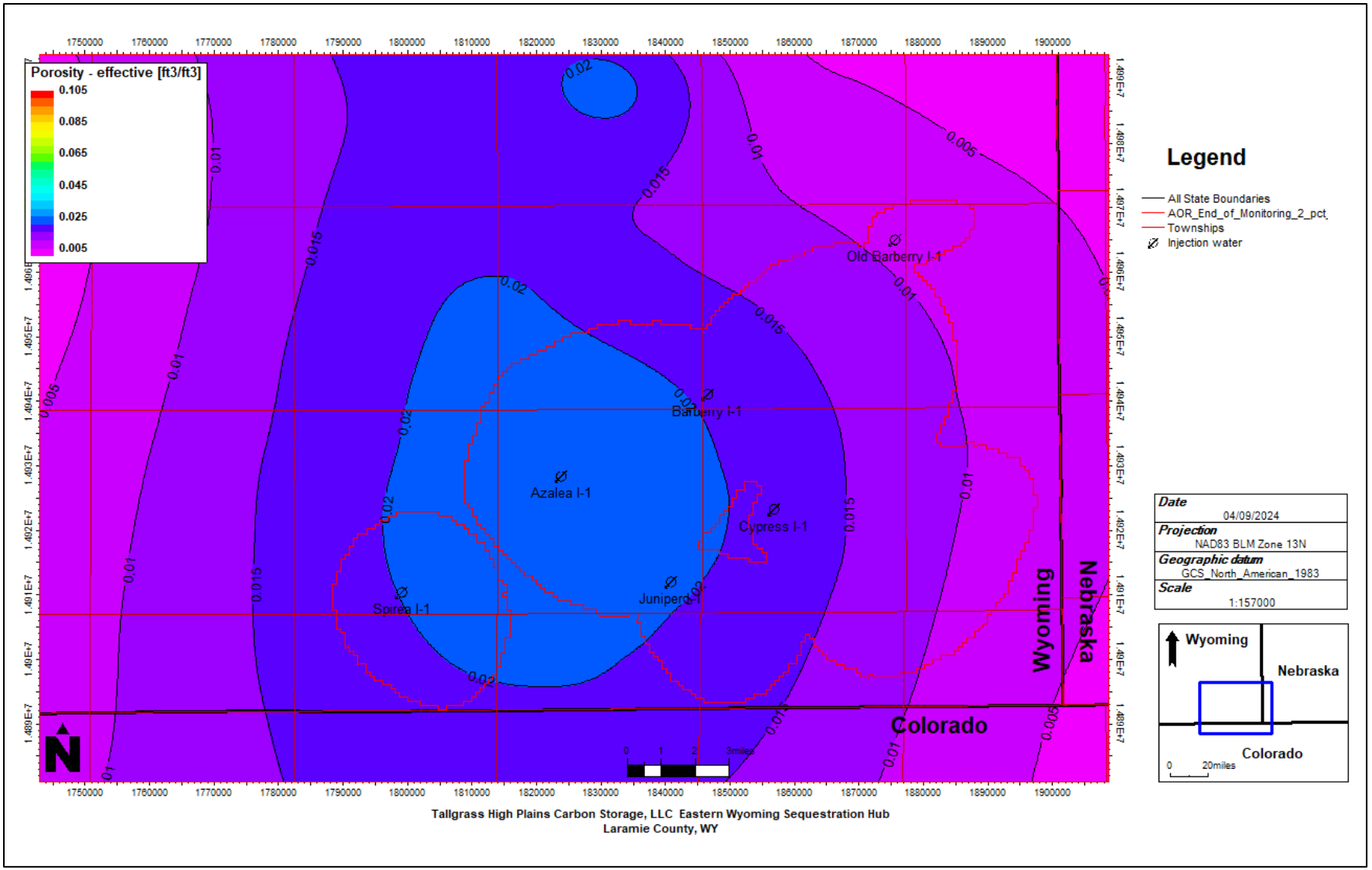
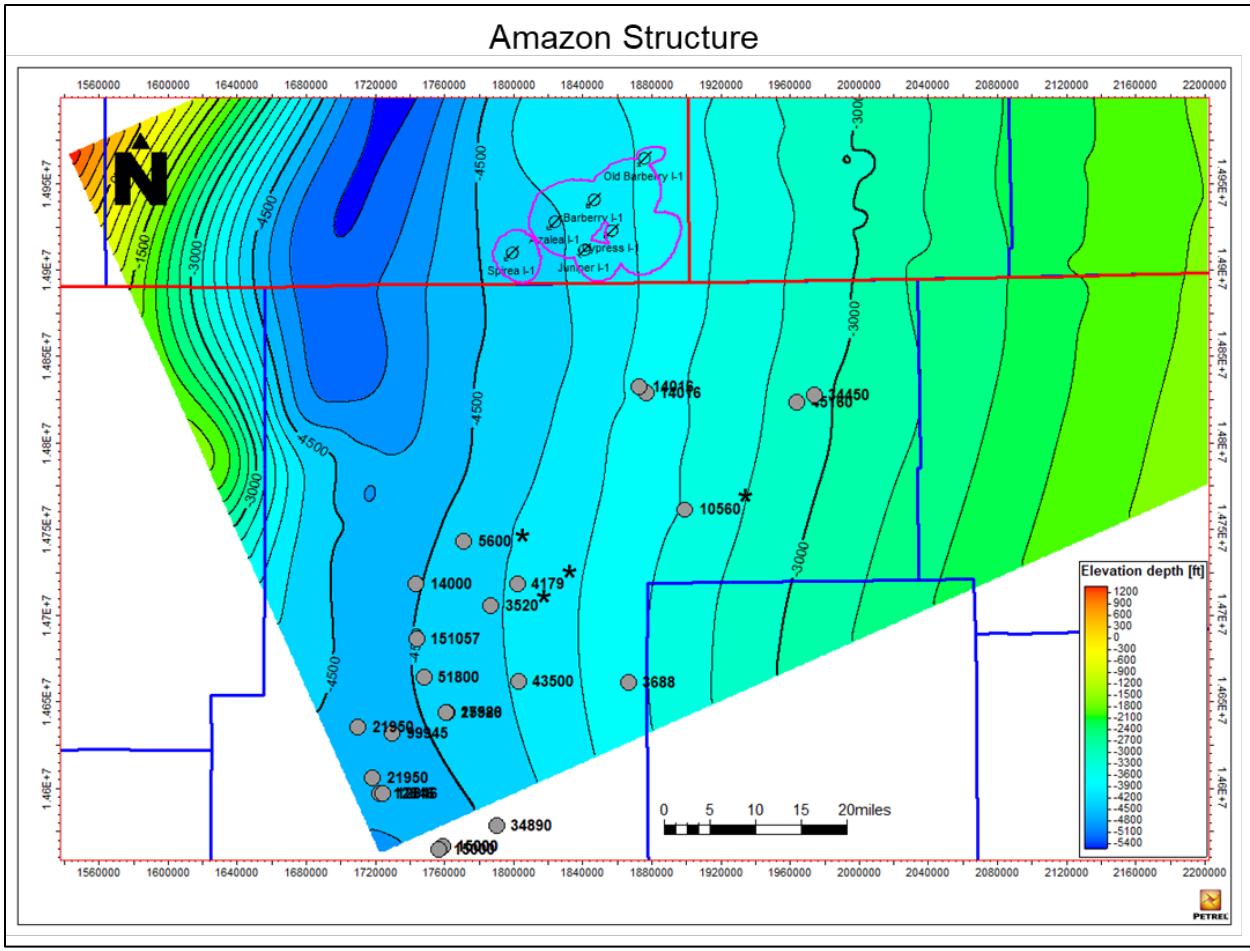



*Figure RTC-22. Wolfcamp average effective porosity.*

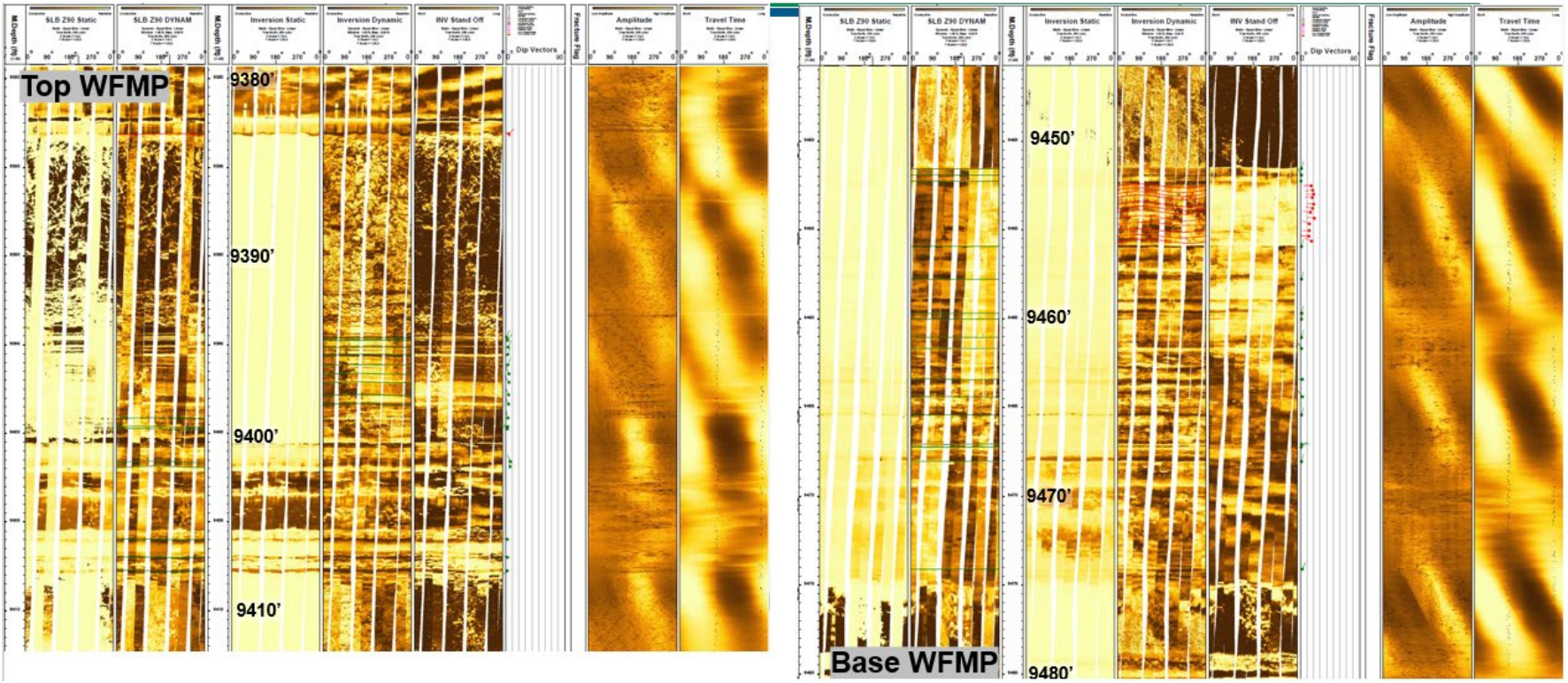
Below the lower confining zone of the Satanka and Wolfcamp formations and ~160 feet from the wellbore TD's is the Amazon formation. The Amazon consists of a barrier shoal facies and average porosities vary from 0-9% across the AoR, making for inconsistent porosity distributions and intraformational flow barriers. Regional water analysis assembled for a 2020 application for Class II injection wells underground disposal of water and aquifer exemption per WOGCC rules by Samson Exploration shows consistent total dissolved solids (TDS) values above 10,000 ppm (see "Application for Class II wells_Samson Energy 2020" in Attachments for full application). Figure RTC-23 has these data plotted on an Amazon structure map where it is reasonable to expect similar salinity trends extend to the High Plains project AoR. This supports the conclusion that the Amazon is not considered a USDW.




| WELL | Amazon |
|---|---|
| DILLARD AB 10-01 | 5600* |
| SWD C7A | 4179* |
| NGL C11 | 3688* |
| NGL APOLLO 11 | 3520* |
| EWS 2 | 151,057 |
| NGL C3B | 99,945 |
| HPD KERSEY 1 | 51,800 |
| RAZOR 26J-2633L | 45,160 |
| NGL C12 | 43,500 |
| EWS 4A | 34,890 |
| HORSETAIL 19N-1924M-R | 34,450 |
| NGL C1C | 25,920 |
| TRITON 1 | 21,950 |
| HPD PLATTEVILLE 1 | 21,950 |
| SWD 1-8B | 17,586 |
| NGL C5 | 15,000 |
| NGL C5A | 15,000 |
| NGL C5B | 15,000 |
| NGL C9B | 14,016 |
| NGL C9 | 14,016 |
| NGL C10 | 14,000 |
| NGL C6A | 12,846 |
| SWD 1-30 | 12,846 |
| EWS 1 | 10,560 |

*Figure RTC-23. Amazon structure map with associated TDS from COGCC facility scout cards. *Anomalous data is suspected to be the result of mud filtrate inclusion in the collected sample and deemed unreliable.*

Wellbore integrity and formation damage is a key consideration. High Plains does not anticipate significant alterations to the Wolfcamp formation as a result of drilling operations. Interpretations of an image log taken from the Juniper M-1 do not suggest evidence of natural or drilling-induced fractures (Figure RTC-24) and it is not expected to be any different for the future injection wells. In addition to safe and efficient drilling practices, High Plains will ensure a robust and satisfactory cement job upon well completion.



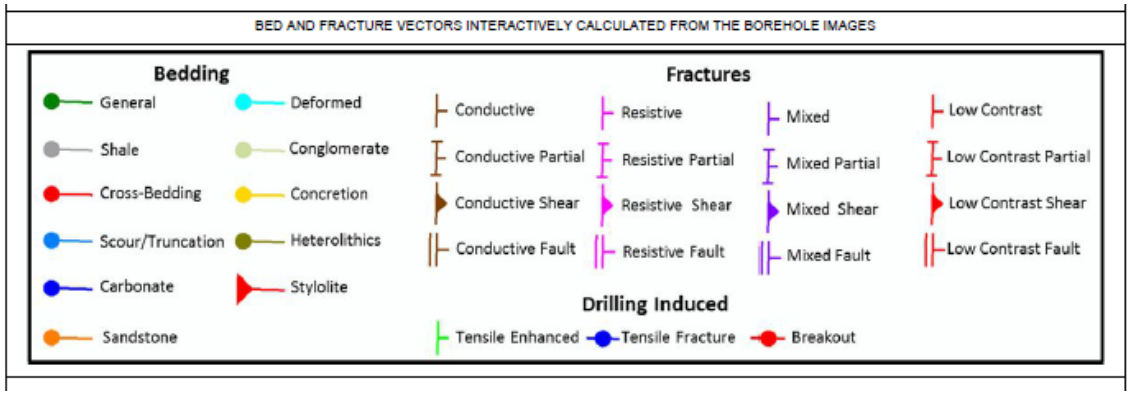




*Figure RTC-24 -Image log of Wolfcamp formation taken from Juniper M-1. There is limited to no evidence of natural or drilling-induced fracturing.*

High Plains remains committed to reducing operational risk and preventable damage to the injection zone and confining units. A reduction in the proposed rat hole will limit the amount of devices on the tool string and, thus, increase the amount of trips in the hole and open hole time. Should the rat hole be shortened then an estimated 80+ hours of extra open hole wireline work would be required which could increase the risk to run casing and obtain a quality cement job. It also increases the chances of tools getting stuck downhole, including tools with nuclear sources. Figure RTC-25 below provides a schematic of a proposed tool configuration that will be used for injection well characterization.

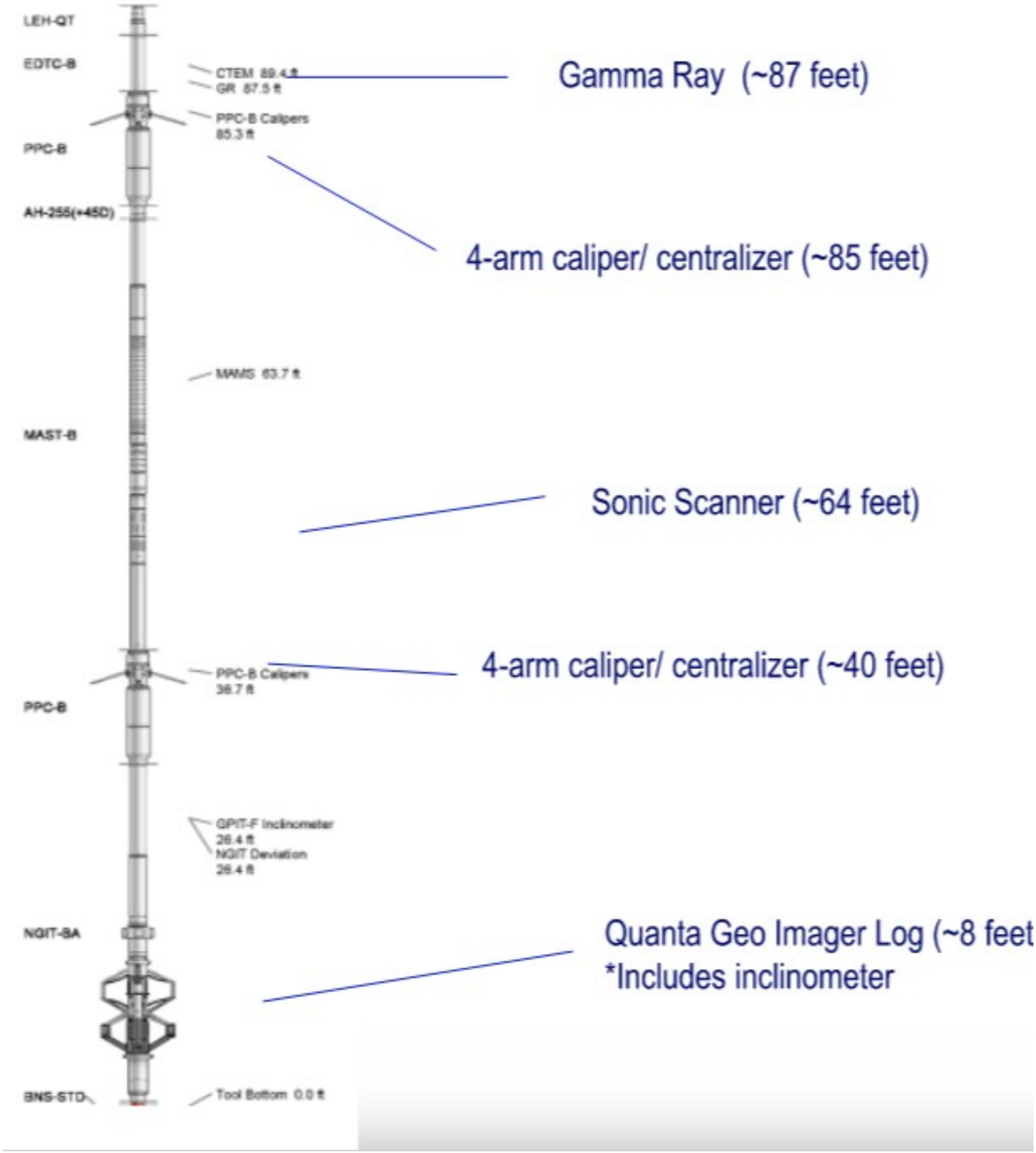



*Figure RTC-25 - Schematic of a proposed tool configuration that will be used for injection well characterization.*

High Plains also proposes a secondary option to mitigate the 130 ft of rathole. Should it remain unfavorable to WDEQ for the injection wells to have 130 ft of cased hole in the lower confining zone during injection, High Plains proposes a $CO_2$ resistant cement plug back to reduce the cased hole to 60 ft post characterization program. The remaining 60 ft of rathole will be utilized during the injection period to run wireline monitoring tools. Should this option be selected as the preferred method, High Plains will modify the casing and cementing plan, the plugging plan, and corrective action as-needed.

**Response to Specific Comments, SC-1**

**Form 1**

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# GEOLOGIC SEQUESTRATION

# PERMIT APPLICATION (Form 1)

## GENERAL INFORMATION AND SIGNATORY AUTHORITY

The geologic sequestration permit application consists of two parts: (1) General Information and Signatory Authority and (2) Technical Information. All sections are to be completed in order to obtain the permit to construct. Operation of a Class VI well is not authorized until authorization to inject is received from the Department. During the construction of the Class VI well, information collected may warrant a permit modification. Only sections pertaining to the modification are required to be completed and public notice requirements will only pertain to those sections being modified. **A pre-application meeting is required prior to this application being submitted.**

**Application Type**

| | | |
|---|---|---|
| UIC Class I Conversion | ☐ | UIC Class I Permit Number: |
| UIC Class II Conversion | ☐ | Hearing Number Recommending Transfer: |
| UIC Class V Conversion | ☐ | UIC Class V Permit Number: |
| New UIC Class VI | ☑ | |
| *UIC Class VI Modification | ☐ | UIC Class VI Permit Number: 2023-041 |

*For Class VI permit modifications, only the sections requiring a modification should be completed. Permit modifications require the signature of the responsible corporate officer as well as the licensed geologist, or licensed engineer, if applicable.

**Public Notice**

In accordance with W.S. 35-11-313(f)(ii)(N), the applicant shall provide notice of the application for the geologic sequestration project proposed. Proof of notice is required to surface owners, mineral claimants, mineral owners, lessees, and other owners of record of subsurface interests that are located within one (1) mile of the proposed boundary of the geologic sequestration site. The publishing of notice of the application is required in a newspaper of general circulation in each county of the proposed operation at weekly intervals for four (4) consecutive weeks. **An affidavit of the notice shall be submitted to WDEQ. Publishing of the notice may not occur more than 14 days following the submission of the permit application.**

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**Wyoming Conservation Executive Orders 2019-3 and 2020-1**

**a. Sage Grouse**

Pursuant to the requirements of the Governor's Executive Order 2019-3 (SGEO), applicants for new UIC permits must determine if any part of the project falls within a Greater Sage-Grouse Core Area (SGCA) before applying. If any part of the project falls within an SGCA, the first point of contact for addressing sage-grouse issues is the Wyoming Game and Fish Department (WGFD). Please coordinate with the WGFD and obtain written confirmation of consistency with the Executive Order prior to applying for a UIC permit and submit this documentation as part of the application package. For more information, contact the Wyoming Game and Fish: Wyoming Game and Fish Department Habitat Protection Program (307) 777-4506 or wgfd.hpp@wyo.gov.
Note that the application shall be returned without processing until a letter confirming consistency with the Executive Order has been obtained. Additional information and maps of SGCAs are available at https://wgfd.wyo.gov/Habitat/Sage-Grouse-Management.

Check one of the following, as applicable to the project:

☐ Some part, or all, of my project falls within an SGCA and I have contacted the WGFD for a SGEO review. A letter from the WGFD confirming consistency with the Executive Order is attached.

☐ Some part, or all, of my project falls within an SGCA and I have contacted the WGFD for a SGEO review. It does not comply with the SGEO. I have valid and existing rights related to this permit. I have committed to the following recommendations that will minimize the impact on the sage grouse.

☑ By checking this box, I certify that I have reviewed the SGCAs available online, and determined that no portion of my project falls within an SGCA. *(No additional requirements apply.)*

**b. Migration Corridors.**

Pursuant to the requirements of the Governor's Executive Order 2020-1, applicants for new UIC permits must determine if any part of the project falls within a Migration Corridor designated under the Executive Order before applying. If any part of the project falls within a Migration Corridor, you must consult with the WGFD. Please coordinate with the WGFD and obtain written confirmation of consistency with the Executive Order prior to applying for a UIC permit and submit this documentation as part of the application package. For more information, contact the Wyoming Game and Fish: Wyoming Game and Fish Department Habitat Protection Program (307) 777-4506 or wgfd.hpp@wyo.gov.
Note that the application shall be returned without processing until a letter confirming consistency with the Executive Order has been obtained. Please also visit the WGFD's Management Page for more information and a map of the currently designated Migration Corridors: https://sites.google.com/view/wywildlifemigrationadvisorygrp/home?fbclid=IwAR3y_HEQxOo4HckAVKzRzT5kdLaOsyiV0vt9NJOtzNu45b_WK0vESwTWVzY#h.bc90kvcpohnu.

Check one of the following, as applicable to the project:

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☐ Some part, or all, of my project falls within the area described and I have contacted the WGFD for consultation. A letter from the WGFD confirming consistency with the Executive Order is attached.

☑ By checking this box, I certify that I have reviewed the Migration Corridors information available online, and determined that no portion of my project falls within a Migration Corridor. *(No additional requirements apply.)*

**1. General Information**

| | | | |
|---|---|---|---|
| Carbon Sequestration Project Name: Eastern Wyoming Sequestration Hub | | | |
| Owner/Operator Name Trailblazer High Plains Carbon Storage, LLC | | | |
| Responsible Corporate Officer Kyle Quackenbush | | Title Segment President & Vice President-Liquids (Crude Oil & CO2) | |
| Telephone Number 303-763-3319 | Email Address kyle.quackenbush@tallgrass.com | | |
| Owner/Operator Address 4200 West 115th Street | City Leawood | State KS | Zip 66211 |

| | | | |
|---|---|---|---|
| Facility Location Address (if different than Operator Address) | City | State | Zip |
| Telephone Number NAD 1983 Lat: 41.052367 Long: -104.3424469 SWNW Sec 34 T13N R63W | | | |
| Facility Mailing Address (if different than Operator Address) | City | State | Zip |
| Telephone Number | | | |

| | | | |
|---|---|---|---|
| Consultant Name Numeric Solutions, LLC | Primary Contact Name Eric White | | |
| Consultant Address 1536 Eastman Ave Ste D | City Ventura | State CA | Zip 93003 |
| Telephone Number 805-794-5011 | Email Address eric.white@numericsolutions.com | | |
| May they be contacted directly? ☐ Yes ☑ No | | | |

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**2. Site and Facility Description**

A description of the proposed geologic sequestration facility and documentation sufficient to demonstrate that the applicant has all legal rights, including but not limited to the right to surface use, necessary to sequester carbon dioxide and associated constituents into the proposed geologic sequestration site.

| |
|---|
| The proposed Eastern Wyoming Sequestration Hub (EWS Hub) will be located in the southeastern corner of Wyoming, in Laramie County, Section 8, Township 13N, Range 62W. Additional documentation will be provided as available. |

**3. SIC Codes**

| | | |
|---|---|---|
| List in descending order of significance the four (4) digit "Standard Industrial Classification Manual" which best describes your facility in terms of the principal products or services you produce or provide. Also, specify each classification in words. | 1st | Code/Name 4619 - Pipelines, not elsewhere classified |
| | 2nd | Code/Name 4953 - Refuse systems (Nonhazardous water disposal sites) |
| | 3rd | Code/Name |
| | 4th | Code/Name |

**4. Water Quality Management Plan, Wellhead Protection Area, Source Water Protection Area**

| | | |
|---|---|---|
| Is the Geologic Sequestration Project within a state-approved water quality management plan area? | YES ☐ | NO ☑ |
| Is the Geologic Sequestration Project within a state-approved wellhead protection area? | YES ☐ | NO ☑ |
| Is the Geologic Sequestration Project within a state-approved source water protection area? | YES ☐ | NO ☑ |

**5. Mineral and Surface Ownership for Area of Review**

| | | | | | | |
|---|---|---|---|---|---|---|
| Mineral Ownership: | ☐ | Applicant | ☐ | Surface Owner | ☐ | State |
| | ☐ | Fed | Mineral Lease # See technical report | | | |

| | | | | |
|---|---|---|---|---|
| Surface Ownership: | ☐ Applicant | ☐ State | ☐ Fed | ☐ Indian Lands (Contact EPA Region 8) |
| | ☑ Private (Specify) Lease | | | ☐ Other (Specify)_____ |

| |
|---|
| Is the facility located on any historic or archeological site? Yes ☐ No ☑ |

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## 6. Contact Information

The owner or operator shall provide a list of contacts for Tribes on Indian lands within the geologic sequestration project as defined by the Area of Review.

Attach a legal description of land ownership within the Area of Review. List ownership by tract or submit in plat form.

## 7. Access for Inspections

Wyoming Statute (W.S.) 35-11-303 (a) states: "the administrator of the water quality division at the direction of the director: (i) may conduct on-site compliance inspections of all facilities and work during or following the completion of any construction, installation or modification for which a permit is issued under W.S. 35-11-301 (a)(ii)."

As part of its application, the applicant shall certify under penalty of perjury that the applicant has secured and shall maintain permission for WDEQ personnel to access the permitted facility, including (i) permission to access the land where the facility is located, (ii) permission to collect resource data as defined by W.S. § 6-3-414, and (iii) permission to enter and cross all properties necessary to access the facility if the facility cannot be directly accessed from a public road. A map of the access route(s) to the facility shall accompany the application.

> *I,* Kyle Quackenbush *, certify under penalty of perjury that the applicant has secured and shall maintain permission for WDEQ personnel and their invitees to access the permitted facility, including (i) permission to access the land where the facility is located, (ii) permission to collect resource data as defined by Wyoming Statute § 6-3-414, and (iii) permission to enter and cross all properties necessary to access the facility if the facility cannot be directly accessed from a public road.*

## 8. Comments

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**9. Certification**

All applications for permits, reports, or information submitted to the Administrator shall be signed by a responsible corporate officer.

| | | |
|---|---|---|
| "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of a fine and imprisonment for knowing violations." | | |
| Signature DocuSigned by: Kyle Quackenbush 95601045D45742D... | Printed Name Kyle Quackenbush | |
| Title Segment President and VP - Liquids (Crude Oil and CO2) | | Date 12/21/2023 |

**10. Carbon Dioxide Stream Exclusion**

The definition of the "carbon dioxide stream" means carbon dioxide, plus associated substances derived from the source materials and any processing, and any substances added to the stream to enable or improve the injection process. Within Chapter 24, the term "carbon dioxide stream" does not include any carbon dioxide stream that meets the definition of a hazardous waste under 40 CFR 261.3. Any Class VI UIC well owner or operator, who claims that a carbon dioxide stream is excluded under paragraph (h) of 40 CFR 261.4 must have an authorized representative (as defined in WWQR Chapter 24 Section 2(mm)) sign a certification statement worded as follows:

| | | |
|---|---|---|
| "I certify under penalty of law that the carbon dioxide stream that I am claiming to be excluded under 40 CR 261.4(h) has not been mixed with, or otherwise co-injected with, hazardous waste at the UIC Class VI permitted facility, and that injection of the carbon dioxide stream is in compliance with the applicable requirements for UIC Class VI wells, including the applicable requirements in WWQR Chapter 24." | | |
| Signature DocuSigned by: Kyle Quackenbush 95601045D45742D... | Printed Name Kyle Quackenbush | |
| Title Segment President and VP - Liquids (Crude Oil and CO2) | | Date 12/21/2023 |

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# GEOLOGIC SEQUESTRATION

## PERMIT APPLICATION

## TECHNICAL INFORMATION

The geologic sequestration permit application consists of two parts: General Information and Signatory Authority and Technical Information. Operation of a Class VI well is not authorized until authorization to inject is received from the department. During the construction of the Class VI well, information collected may warrant a permit modification. Modifications will only require sections pertaining to the modification to be completed and public notice requirements will only pertain to those sections being modified.

**To expedite the review of the permit application, an application report template is provided.** The following Table of Contents and text identifies the various sections with accompanying figures, tables, and appendices to accompany the application. All sections should be completed. If a section is not applicable, please state such in the document.

If data is not available but will be collected during well construction activities, please incorporate work plans describing the work to be completed where the text indicates as-builts or collected data. After the information is collected during well construction activities, those sections of the permit application may be revised as part of the permit modification to include as-builts and data collected. Additional figures and tables may be incorporated into the document and renamed to reflect site-specific information.

A Word document is provided to assist with completing the document. The italicized text should be deleted and replaced with site-specific information. If you have additional questions or need further clarification, please contact Lily Barkau at (307) 777-7072 or lily.barkau@wyo.gov or Graeme Finley at (307) 473-3478 or graeme.finley@wyo.gov.

**Response to Specific Comments, SC-4**

**Juniper M-1 Rock Mechanics Data Report**

# GEOMECHANICAL ANALYSIS

## Conventional Core Plug Samples

Triaxial Compressive Strength (TXC)
Pore Volume Compressibility (PVC)
In-Direct Tensile Strength (Brazil)
Fracture Toughness
Creep Testing

**FINAL DATA REPORT**

# Devon Energy LLC

Tallgrass - Juniper M1
Laramie County, Wyoming

**Performed by**
Premier Corex
11335 Clay Road, Suite 180
Houston, Texas 77041
Abhijit Mitra, Senior Geomechanics Advisor

**Report Issued**
November 29, 2023

**Project Number**
23-0114

# GEOMECHANICAL REPORT

Conventional Core Plug Samples
Multi-Stage Triaxial Compressive Strength (MTXC) Testing

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114

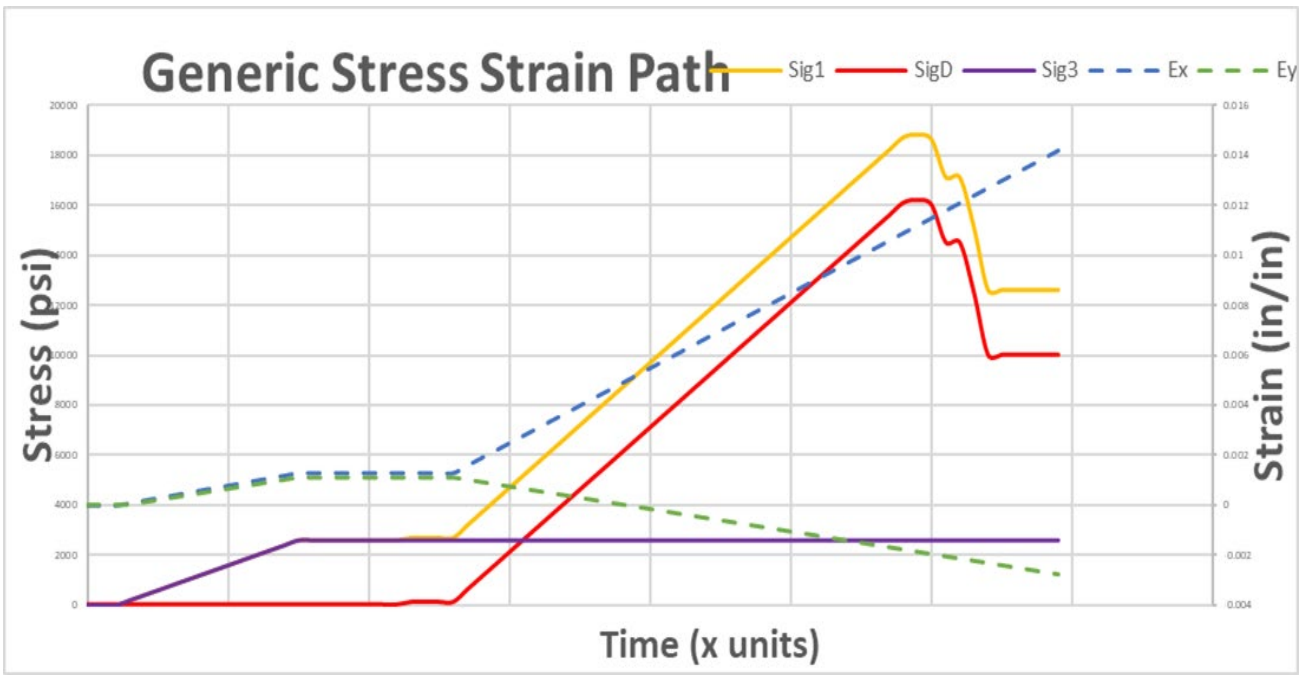
## Testing Overview

Two distinct testing protocols were used in conjunction for the scope of testing for this project. First, Multi-Stage triaxial testing was conducted to demonstrate mechanical properties of a given interval of core, through varying horizontal stress conditions (to simulate drawdown). This data can be used for a more thorough understanding of a given materials' mechanical properties and behaviors through varying reservoir stress states through its expected lifecycle.

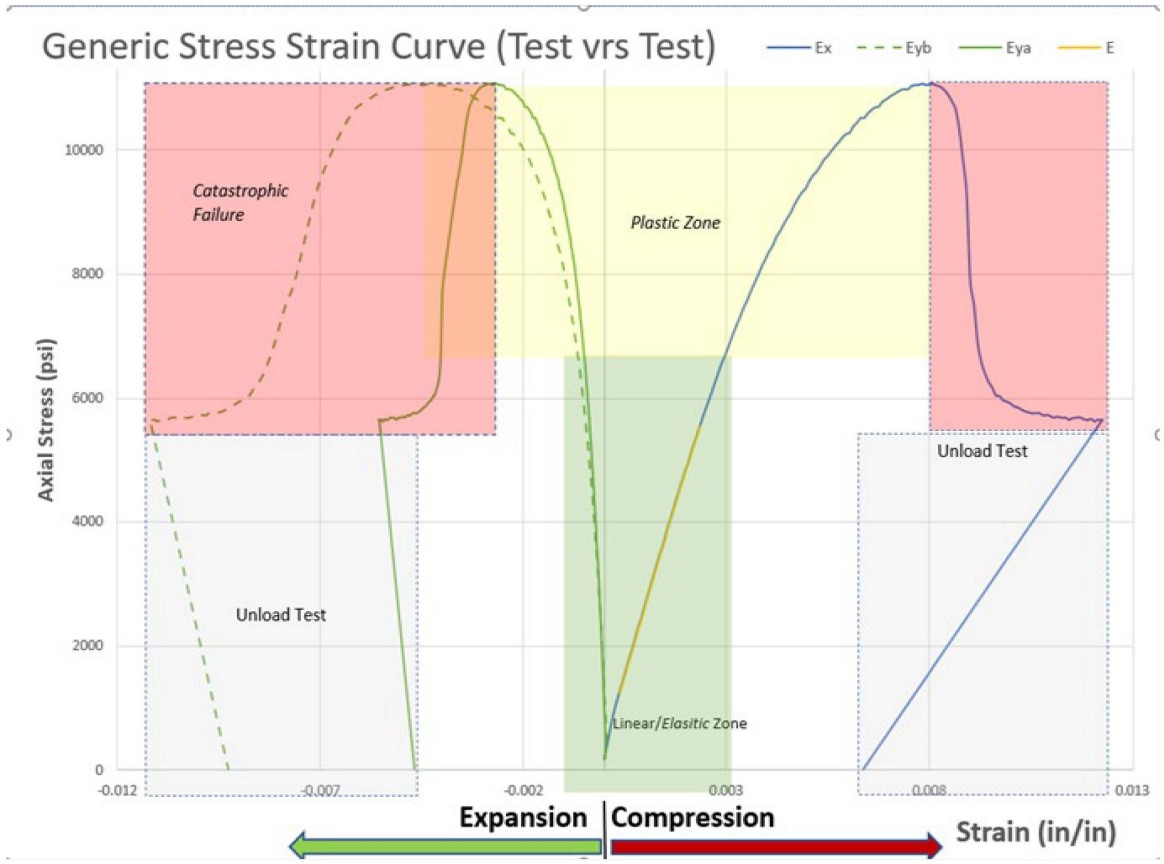
The second test protocol utilized is described as Anisotropic Testing. This phase was completed by the addition of a single HRZ sample at each interval group. The addition of a single sample allowed for the testing of anisotropic properties and behaviors in each interval. These properties can be used for a deeper understanding of reservoir behavior and often used for log calibration, as modeling inputs and in frac-design.

For all testing (MTXC and AT), individual samples were tested triaxially for each defined HRZ stress condition. Each sample was loaded via axial strain control at 1e-6 in/in/sec through sample failure. Samples were unloaded after reaching "residual" stress conditions or in the case of a jacket failure post test. UCS tests were unloaded immediately post failure. Testing was conducted in accordance to the following references:

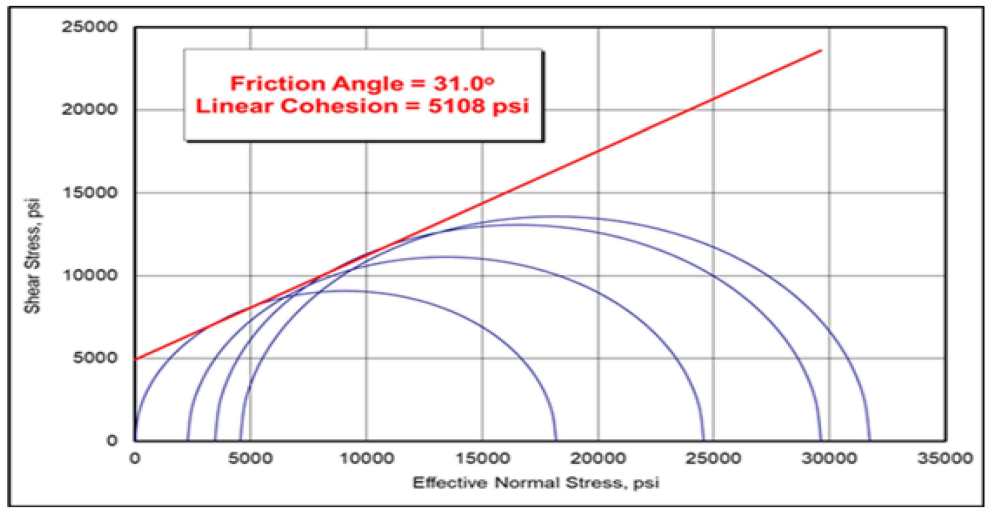
- *ASTM- D7012-14e1 Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures*
- *ISRM- Suggested Methods for Rock Characterization Testing and Monitoring.*
- *Developments in Petroleum Science, Vol 64 Chapter 12.4*



Generic Triaxial Test




Generic Mohr's Coulomb/Failure Envelope



# GEOMECHANICAL REPORT

Conventional Core Plug Samples
Multi-Stage Triaxial Compressive Strength (MTXC) Testing

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114

## Testing Setup

***Sample size***: All samples were verified to meet defined ASTM standards (2:1 length to diameter ratio, parallel within 0.001" 90-degree cylinder) in respect to Rock Mechanics testing. Sample size was 1" x 2" plugs. Parallelism was verified within 0.0005'. Sample length to diameter ratio was reported for each plug in the sample description overview. Acceptable tolerance from 1.85 to 2.15.

1. ***Record Sample Information:*** The following information was recorded locally in a testing lab notebook and in DAQ software prior to testing: length, diameter, mass, density, orientation, depth and horizontal stress conditions.

2. ***Build Sample Stack***: A "stack" is constructed consisting of a plug sandwiched between (2) Acoustic Endcaps (AEC). Axial and radial deformation sensors are attached and verified for alignment.

3. ***Load Stack in Testing Vessel:*** Sample record information is verified prior to a completed stack being inserted into the load-frame. All sensors are connected to the DAQ system and verified for functionality. Sensor alignment is verified one last time.

## General Testing Procedures

1. ***Triaxial Compression Tests (all tests) (TXC)***: A segment test is defined/modified and initiated. The sample stack is then lifted into the pressure vessel and aligned on a reaction column. The pressure vessel is filled with oil. After stabilization is observed, horizontal In-situ stress is applied via confining pressure at a defined rate (3 psi/sec). After strain stabilization is observed, the load piston is applied in strain control at 1e-6 in/in/sec through sample failure. Tests are unloaded after reaching "residual" stress.

   Static and Dynamic data are monitored and collected throughout the entirety of the test.

   ***Unconfined Compressive Strength Tests (UCS)***: UCS tests are nearly identical to TXC tests. The difference being that UCS tests do not use a confining fluid for horizontal stress and thus are conducted at ambient conditions. UCS tests are also immediately unloaded post failure.

2. ***Quality Control Initial Results***: All samples are visually inspected prior to testing. uCT is referenced for sample selection and QA purposes.

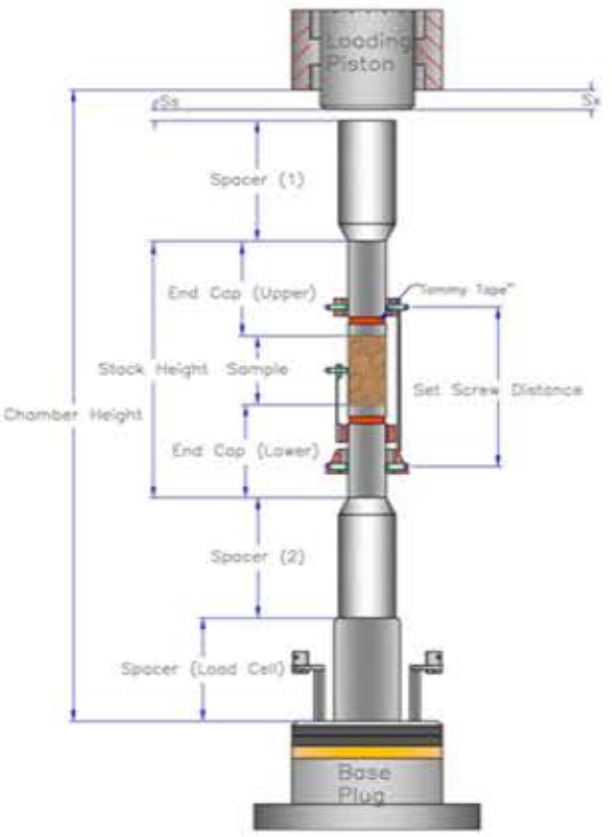
In-test deformation and strain behavior are monitored continuously and evaluated for consistency. Any non-physical/suspect behavior observed results in the test being unloaded.

An example of "non-physical" behavior is observing the sample diameter increasing (getting bigger) through a hydrostatic pressure increase. This is generally caused by a jacket leak where confining oil gains access to inside the sample stack.

Test results are monitored real time and evaluated for viability, and against similar known materials and expected behaviors. Bulk densities are compared for a set of sister samples. Calculated values such as Young's Modulus and Poisson's ratio are monitored in-test and evaluated for feasibility. An example of a "red flag" would be observing a Poisson's ratio greater than 0.5 or less than 0.1. This could be caused by a poor-quality stack build, sensor alignment issues, or an already failed/poor quality sample.

3. ***Post-Test Processing.*** The sample is removed from the load frame, stack and placed in its original sample bag. A post-test photograph is taken. Test data is reduced and transferred to the local POFG network. Data analysis and reporting is then completed.

## Sample Stack




## Measurement Confidence

Individual measurement confidence is defined as below.

| Measurement | Confidence Level | Uncertainty Level |
|---|---|---|
| Axial Displacement/Strain | High | Low |
| Force/Axial Stress | Very High | Very Low |
| Confining Stress | Very High | Very Low |
| Radial Deformation/Strain | Medium | Medium |
| Ultrasonic Velocities | Medium-High | Medium-Low |

# GEOMECHANICAL REPORT - Sample List

Conventional Core Plug Samples
TXC, PVC, Brazil, Fracture Toughness, & Creep

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114

| Formation Name | Sample ID | Core Depth (ft) | Test Type name | Sample Orientation | Diameter (in) | Length (in) | L:D ratio | Mass (g) | Bulk Density (g/cc) | Confining Stress (psi) |
|---|---|---|---|---|---|---|---|---|---|---|
| Goose Egg | 4-TXC-H | 8874.35 | TXC | Horizontal | 1.01 | 1.85 | 1.83 | 72.03 | 2.97 | 7500 |
| | 4-TXC-V1 | 8874.45 | TXC | Vertical | 1.01 | 1.87 | 1.85 | 72.48 | 2.95 | 500 |
| | 4-TXC-V2 | 8874.45 | TXC | Vertical | 1.02 | 2.05 | 2.01 | 80.60 | 2.94 | 2500 |
| | 4-TXC-V3 | 8874.45 | TXC | Vertical | 1.01 | 2.05 | 2.03 | 79.00 | 2.94 | 5000 |
| | 4-TXC-V4 | 8874.45 | TXC | Vertical | 1.00 | 2.05 | 2.05 | 79.36 | 3.01 | 7500 |
| | 4-PVC-H | 8874.35 | PVC | Horizontal | 1.01 | 2.04 | 2.02 | 80.07 | 2.99 | 7500 |
| | 4-PVC-V1 | 8874.45 | PVC | Vertical | 1.01 | 2.05 | 2.03 | 80.06 | 2.97 | 7500 |
| | 4-PVC-V2 | 8874.45 | PVC | Vertical | 1.00 | 2.00 | 2.00 | 76.64 | 2.98 | 7500 |
| | 4-BRZ-H | 8874.35 | BRZ | Horizontal | 1.01 | 0.54 | 0.53 | 21.09 | 2.97 | 0 |
| | 4-BRZ-H90 | 8874.35 | BRZ | Horizontal | 1.01 | 0.50 | 0.50 | 19.18 | 2.92 | 0 |
| | 4-BRZ-V | 8874.45 | BRZ | Vertical | 1.00 | 0.50 | 0.50 | 19.20 | 2.98 | 0 |
| Minnektahta | 5-PVC-H | 9017.70 | PVC | Horizontal | 1.04 | 1.85 | 1.78 | | 0.00 | |
| | 5-PVC-H1 | 9017.70 | PVC | Horizontal | | | | | | |
| | 5-PVC-H2 | 9017.90 | PVC | Horizontal | 1.40 | 2.04 | 1.46 | | 0.00 | |
| | 5-PVC-V1 | 9017.30 | PVC | Vertical | 1.00 | 1.70 | 1.70 | | 0.00 | |
| Minnektahta | 6-TXC-H | 9030.13 | TXC | Horizontal | 1.01 | 1.81 | 1.79 | 70.25 | 2.96 | 7500 |
| | 6-TXC-V1 | 9030.23 | TXC | Vertical | 1.01 | 1.99 | 1.97 | 76.86 | 2.94 | 500 |
| | 6-TXC-V2 | 9030.23 | TXC | Vertical | 1.00 | 2.05 | 2.05 | 76.79 | 2.91 | 2500 |
| | 6-TXC-V3 | 9030.23 | TXC | Vertical | 1.02 | 2.05 | 2.01 | 79.86 | 2.91 | 5000 |
| | 6-TXC-V4 | 9030.23 | TXC | Vertical | 1.00 | 2.04 | 2.04 | 77.81 | 2.96 | 7500 |
| | 6-PVC-H | 9030.13 | PVC | Horizontal | 1.00 | 1.96 | 1.96 | 74.55 | 2.96 | 7500 |
| | 6-PVC-V1 | 9030.23 | PVC | Vertical | 1.02 | 1.93 | 1.89 | 76.05 | 2.94 | 7500 |
| | 6-PVC-V2 | 9029.45 | PVC | Vertical | 1.00 | 1.98 | 1.98 | 74.58 | 2.93 | 7500 |
| | 6-BRZ-H | 9030.13 | BRZ | Horizontal | 1.01 | 0.57 | 0.56 | 22.16 | 2.96 | 0 |
| | 6-BRZ-H2 | 9029.45 | BRZ | Horizontal | 1.01 | 0.53 | 0.52 | 20.97 | 3.01 | 0 |
| | 6-BRZ-H90 | 9030.13 | BRZ | Horizontal | 1.01 | 0.53 | 0.52 | 20.56 | 2.95 | 0 |
| | 6-BRZ-H90-2 | 9029.45 | BRZ | Vertical | 1.01 | 0.54 | 0.53 | 21.18 | 2.99 | 0 |
| | 6-BRZ-V | 9030.23 | BRZ | Vertical | 1.01 | 0.53 | 0.52 | 20.45 | 2.94 | 0 |
| Blaine | 7-TXC-H | 9070.23 | TXC | Horizontal | 1.00 | 2.04 | 2.04 | 77.43 | 2.95 | 7500 |
| | 7-TXC-V1 | 9070.00 | TXC | Vertical | 1.00 | 1.86 | 1.86 | 77.50 | 3.24 | 500 |
| | 7-TXC-V2 | 9070.00 | TXC | Vertical | 1.00 | 2.03 | 2.03 | 77.18 | 2.95 | 2500 |
| | 7-TXC-V3 | 9070.00 | TXC | Vertical | 1.00 | 2.03 | 2.03 | 76.79 | 2.94 | 5000 |
| | 7-TXC-V4 | 9070.00 | TXC | Vertical | 1.00 | 2.03 | 2.03 | 77.12 | 2.95 | 7500 |
| | 7-PVC-H | 9070.23 | PVC | Horizontal | 1.00 | 1.92 | 1.92 | 73.70 | 2.98 | 7500 |
| | 7-PVC-V1 | 9070.54 | PVC | Vertical | 1.00 | 2.03 | 2.03 | 77.30 | 2.96 | 7500 |
| | 7-BRZ-H | 9070.23 | BRZ | Horizontal | 1.00 | 0.52 | 0.52 | 19.84 | 2.96 | 0 |
| | 7-BRZ-H90 | 9070.23 | BRZ | Horizontal | 1.00 | 0.49 | 0.49 | 18.31 | 2.90 | 0 |
| | 7-BRZ-V | 9070.00 | BRZ | Vertical | 1.00 | 0.52 | 0.52 | 18.31 | 2.74 | 0 |
| | 7-CRP-V | 9070.80 | CRP | Vertical | 1.50 | 2.45 | 1.63 | 196.50 | 2.77 | 7500 |

# GEOMECHANICAL REPORT - Sample List

Conventional Core Plug Samples
TXC, PVC, Brazil, Fracture Toughness, & Creep

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114

| Formation Name | Sample ID | Core Depth (ft) | Test Type name | Sample Orientation | Diameter (in) | Length (in) | L:D ratio | Mass (g) | Bulk Density (g/cc) | Confining Stress (psi) |
|---|---|---|---|---|---|---|---|---|---|---|
| Flowerpot | 8-TXC-H | 9110.40 | TXC | Horizontal | 1.00 | 1.98 | 1.98 | 68.50 | 2.69 | 7500 |
| | 8-TXC-V1 | 9110.00 | TXC | Vertical | 1.00 | 1.88 | 1.88 | 64.98 | 2.69 | 500 |
| | 8-TXC-V2 | 9110.00 | TXC | Vertical | 1.00 | 2.04 | 2.04 | 71.50 | 2.72 | 2500 |
| | 8-TXC-V3 | 9110.00 | TXC | Vertical | 1.00 | 2.01 | 2.01 | 70.50 | 2.73 | 5000 |
| | 8-TXC-V4 | 9110.00 | TXC | Vertical | 1.00 | 2.03 | 2.03 | 71.17 | 2.72 | 7500 |
| | 8-PVC-H | 9110.40 | PVC | Horizontal | 1.00 | 2.05 | 2.05 | 70.75 | 2.68 | 7500 |
| | 8-PVC-V1 | 9110.00 | PVC | Vertical | 1.00 | 2.04 | 2.04 | 71.29 | 2.72 | 7500 |
| | 8-BRZ-H | 9110.40 | BRZ | Horizontal | 1.00 | 0.55 | 0.55 | 19.13 | 2.70 | 0 |
| | 8-BRZ-H90 | 9110.40 | BRZ | Horizontal | 1.00 | 0.50 | 0.50 | 17.44 | 2.71 | 0 |
| | 8-BRZ-V | 9110.00 | BRZ | Vertical | 1.00 | 0.52 | 0.52 | 18.01 | 2.69 | 0 |
| Lyons | 9-TXC-H | 9155.25 | TXC | Horizontal | 1.00 | 2.03 | 2.03 | 57.92 | 2.22 | 5000 |
| | 9-TXC-V1 | 9155.00 | TXC | Vertical | 1.00 | 2.05 | 2.05 | 58.39 | 2.21 | 500 |
| | 9-TXC-V2 | 9155.00 | TXC | Vertical | 1.00 | 2.00 | 2.00 | 56.60 | 2.20 | 2500 |
| | 9-TXC-V3 | 9155.00 | TXC | Vertical | 1.00 | 2.04 | 2.04 | 58.29 | 2.22 | 5000 |
| | 9-TXC-V4 | 9155.00 | TXC | Vertical | 1.00 | 2.03 | 2.03 | 58.28 | 2.23 | 7500 |
| | 9-PVC-H | 9155.25 | PVC | Horizontal | 1.00 | 2.05 | 2.05 | 57.91 | 2.19 | 5000 |
| | 9-PVC-V1 | 9155.00 | PVC | Vertical | 1.00 | 2.03 | 2.03 | 57.31 | 2.19 | 5000 |
| | 9-BRZ-H | 9155.25 | BRZ | Horizontal | 1.00 | 0.54 | 0.54 | 15.05 | 2.17 | 0 |
| | 9-BRZ-H90 | 9155.25 | BRZ | Horizontal | 1.00 | 0.51 | 0.51 | 14.56 | 2.22 | 0 |
| | 9-BRZ-V | 9155.00 | BRZ | Vertical | 1.00 | 0.51 | 0.51 | 14.16 | 2.16 | 0 |
| | 9-FT-H | 9155.25 | FT | Horizontal | 1.00 | 0.55 | 0.55 | 16.25 | 2.30 | 5000 |
| Satanka | 10-TXC-H | 9184.35 | TXC | Horizontal | 1.00 | 2.02 | 2.02 | 68.65 | 2.64 | 7500 |
| | 10-TXC-V1 | 9184.45 | TXC | Vertical | 1.00 | 2.00 | 2.00 | 67.93 | 2.64 | 500 |
| | 10-TXC-V2 | 9184.45 | TXC | Vertical | 1.00 | 2.02 | 2.02 | 68.70 | 2.64 | 2500 |
| | 10-TXC-V3 | 9184.45 | TXC | Vertical | 1.00 | 2.00 | 2.00 | 68.00 | 2.64 | 5000 |
| | 10-TXC-V4 | 9184.45 | TXC | Vertical | 1.00 | 2.02 | 2.02 | 68.55 | 2.64 | 7500 |
| | 10-PVC-H | 9184.35 | PVC | Horizontal | 1.00 | 1.70 | 1.70 | 57.60 | 2.63 | 7500 |
| | 10-PVC-V1 | 9184.45 | PVC | Vertical | 1.00 | 2.04 | 2.04 | 72.70 | 2.77 | 7500 |
| | 10-BRZ-H | 9184.35 | BRZ | Horizontal | 1.00 | 0.57 | 0.57 | 19.36 | 2.64 | 0 |
| | 10-BRZ-H90 | 9184.35 | BRZ | Horizontal | 1.00 | 0.55 | 0.55 | 20.28 | 2.86 | 0 |
| | 10-BRZ-H90-2 | 9184.35 | BRZ | Horizontal | 1.00 | 0.55 | 0.55 | 20.28 | 2.86 | 0 |
| | 10-BRZ-V | 9184.45 | BRZ | Vertical | 1.00 | 0.46 | 0.46 | 15.46 | 2.61 | 0 |

Notes: Samples in red highlight failed and were replaced or eliminated from testing

# GEOMECHANICAL REPORT - Pore Volume Compressibility

Conventional Core Plug Samples

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114

| Formation Name | Sample ID | Core Depth (ft) | Sample Orientation | Diameter (in) | Length (in) | L:D ratio | Weight (g) | Bulk Density (g/cc) | Young's Modulus (psi) | Poisson's Ratio A negative | Poisson's Ratio B negative | Bulk Modulus (psi) | Bulk Compressibility (1/psi) | Ko (psi) | Grain Compressibility (1/psi) | Alpha 1-Cg/Cb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Goose Egg | *4-PVC-V2 | 8874.45 | Vertical | 1.00 | 2.00 | 2.00 | 76.64 | 2.98 | | | | | | | | |
| | 4-PVC-H | 8874.35 | Horizontal | 1.01 | 2.04 | 2.02 | 79.20 | 2.95 | 6.77E+06 | 0.251 | 0.226 | 4.10E+06 | 2.44E-07 | 7.94E+06 | 1.26E-07 | 0.484 |
| Minnektahta | 6-PVC-V2 | 9029.45 | Vertical | 1.00 | 1.98 | 1.98 | 74.58 | 2.93 | 6.79E+06 | 0.155 | 0.239 | 4.45E+06 | 2.25E-07 | 8.77E+06 | 1.14E-07 | 0.493 |
| | 6-PVC-H | 9030.13 | Horizontal | 1.01 | 1.96 | 1.95 | 74.57 | 2.90 | 7.27E+06 | 0.283 | 0.238 | 2.40E+06 | 4.17E-07 | 4.65E+06 | 2.15E-07 | 0.484 |
| Blaine | 7-PVC-V1 | 9070.54 | Vertical | 1.00 | 2.03 | 2.02 | 77.33 | 2.93 | 7.01E+06 | 0.216 | 0.234 | 4.02E+06 | 2.49E-07 | 7.61E+06 | 1.31E-07 | 0.472 |
| | 7-PVC-H | 9070.23 | Horizontal | 1.00 | 1.94 | 1.95 | 73.69 | 2.95 | 7.99E+06 | 0.238 | 0.269 | 4.34E+06 | 2.30E-07 | 7.95E+06 | 1.26E-07 | 0.454 |
| Flowerpot | 8-PVC-V1 | 9110.40 | Vertical | 1.00 | 2.04 | 2.04 | 71.32 | 2.70 | 3.71E+06 | 0.250 | 0.201 | 2.01E+06 | 4.98E-07 | 4.10E+06 | 2.44E-07 | 0.510 |
| | 8-PVC-H | 9110.40 | Horizontal | 1.00 | 2.05 | 2.04 | 70.76 | 2.65 | 4.85E+06 | 0.244 | 0.300 | 1.85E+06 | 5.41E-07 | 3.79E+06 | 2.64E-07 | 0.512 |
| Lyons | 9-PVC-V1 | 9155.00 | Vertical | 1.01 | 2.03 | 2.01 | 57.85 | 2.18 | 1.74E+06 | 0.234 | 0.242 | 5.99E+05 | 1.67E-06 | 1.66E+06 | 6.02E-07 | 0.639 |
| | 9-PVC-H | 9155.25 | Horizontal | 1.00 | 2.05 | 2.04 | 58.41 | 2.21 | 1.75E+06 | 0.261 | 0.279 | 6.71E+05 | 1.49E-06 | 1.56E+06 | 6.41E-07 | 0.570 |
| Satanka | 10-PVC-V1 | 9184.45 | Vertical | 1.03 | 2.03 | 1.97 | 72.68 | 2.63 | 5.11E+06 | 0.271 | 0.318 | 2.89E+06 | 3.46E-07 | 8.20E+06 | 1.22E-07 | 0.648 |
| | 10-PVC-H | 9184.35 | Horizontal | 1.00 | 1.70 | 1.70 | 57.60 | 2.64 | 5.02E+06 | 0.240 | 0.221 | 2.82E+06 | 3.55E-07 | 4.96E+06 | 2.02E-07 | 0.431 |

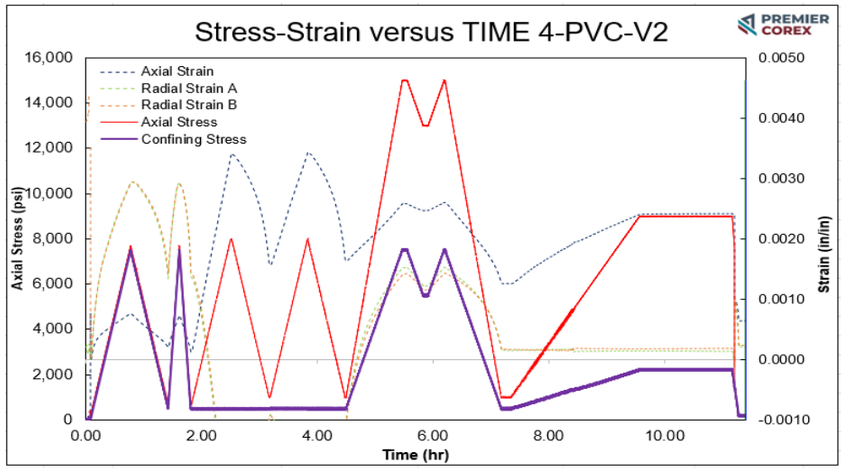
Notes: Blacked out cells indicates no data was collected and/or presented
*Radial deformation during SigmaD ramps (between 2 and 4 hrs.) was too high, suggesting inelastic deformation; Young's modulus, bulk modulus, Ko and Biot's coefficient is not being reported

# Pore Volume Compressibility Plots

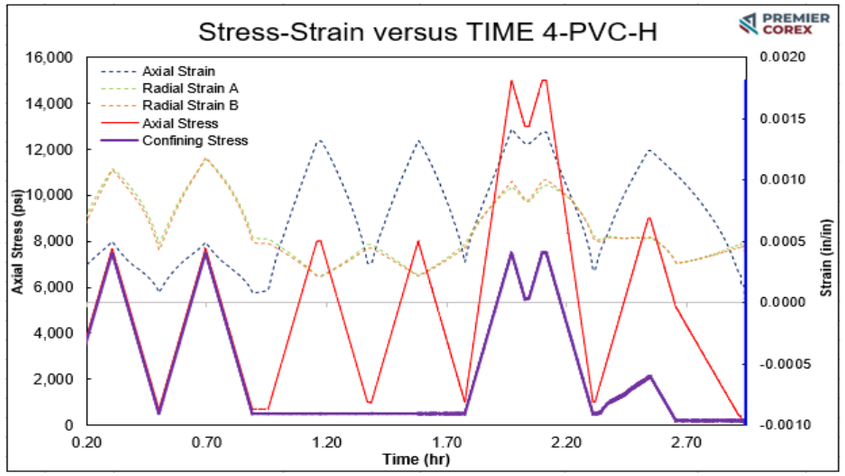
Conventional Core Plug Samples

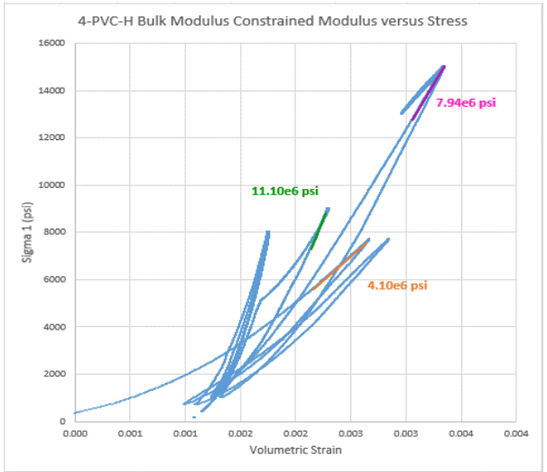
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

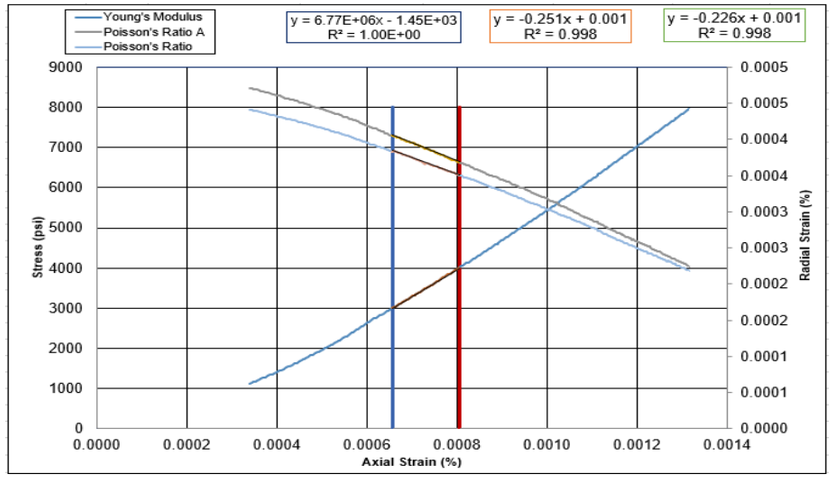
**Report Date:** 11/29/2023
**Project Number:** 23-0114




**Sample 4-PVC-V2: Radial deformation during SigmaD ramps (between 2 and 4 hrs.) was too high, suggesting inelastic deformation; Young's modulus, bulk modulus, K0 and Biot's coefficient is not being reported**



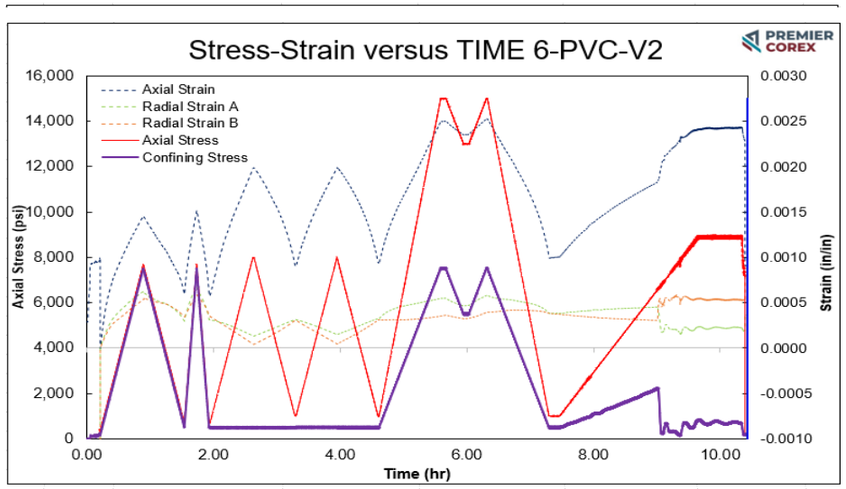



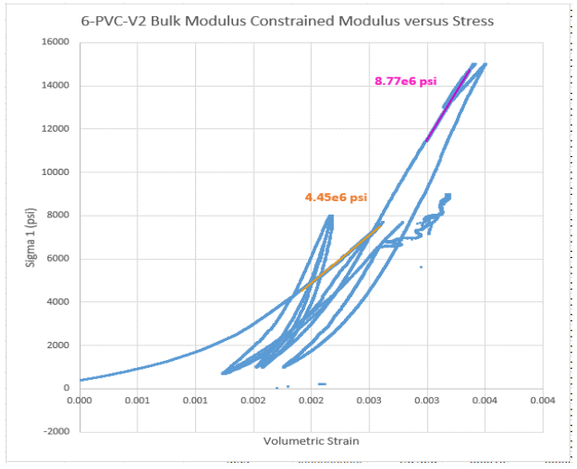
# Pore Volume Compressibility Plots

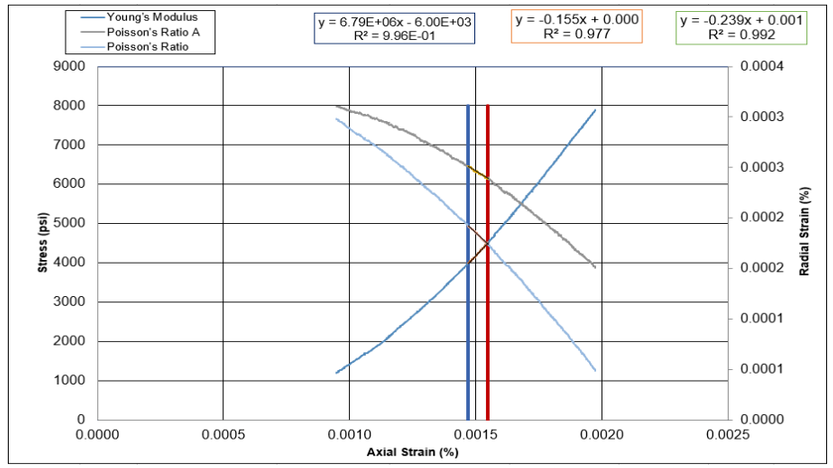
Conventional Core Plug Samples

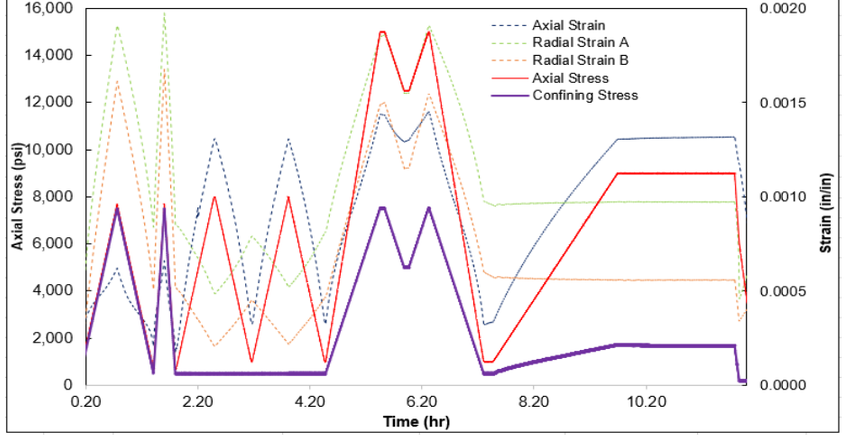
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

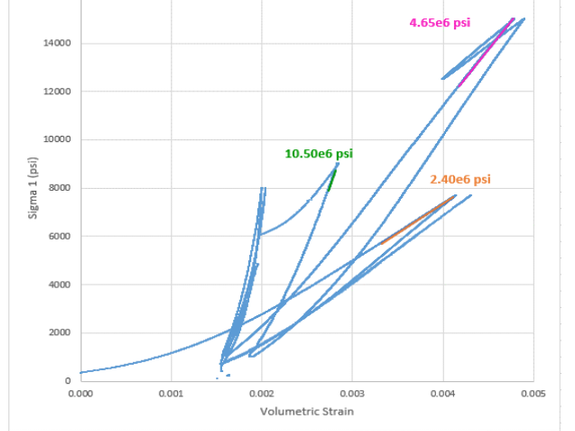
**Report Date:** 11/29/2023
**Project Number:** 23-0114

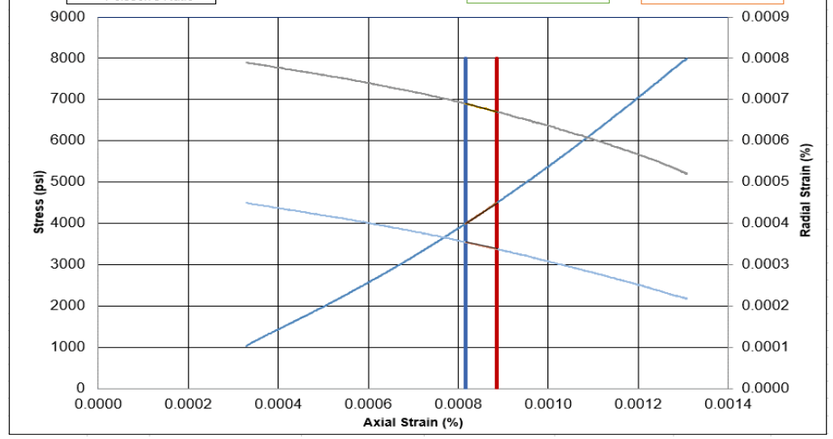


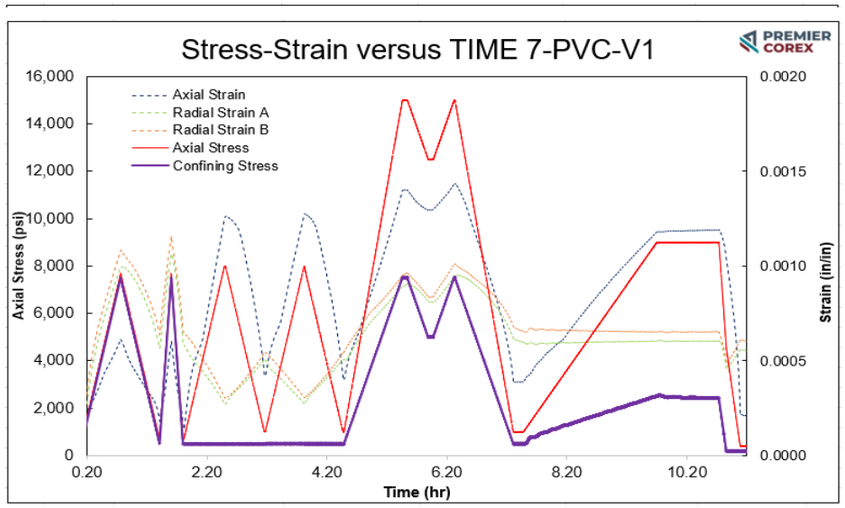



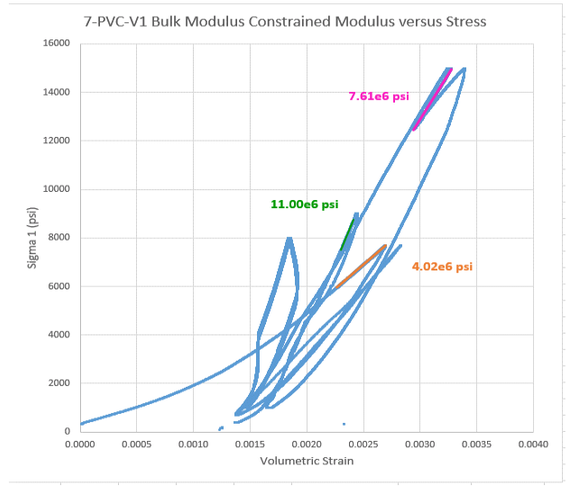
# Pore Volume Compressibility Plots

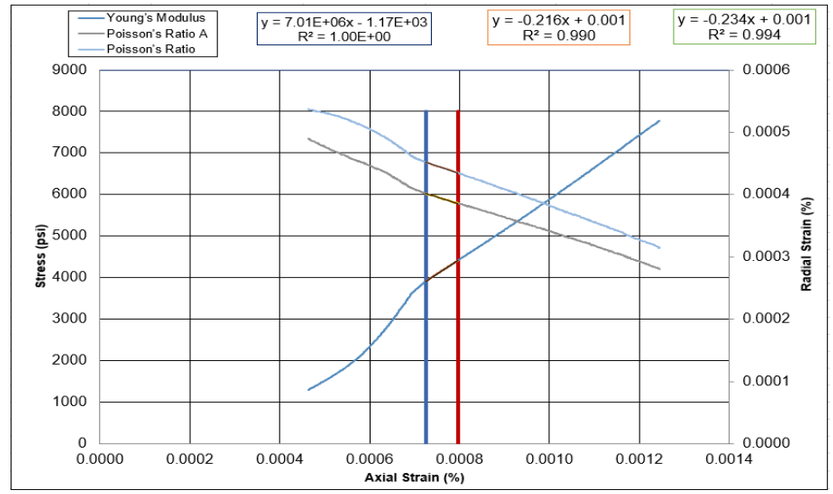
Conventional Core Plug Samples

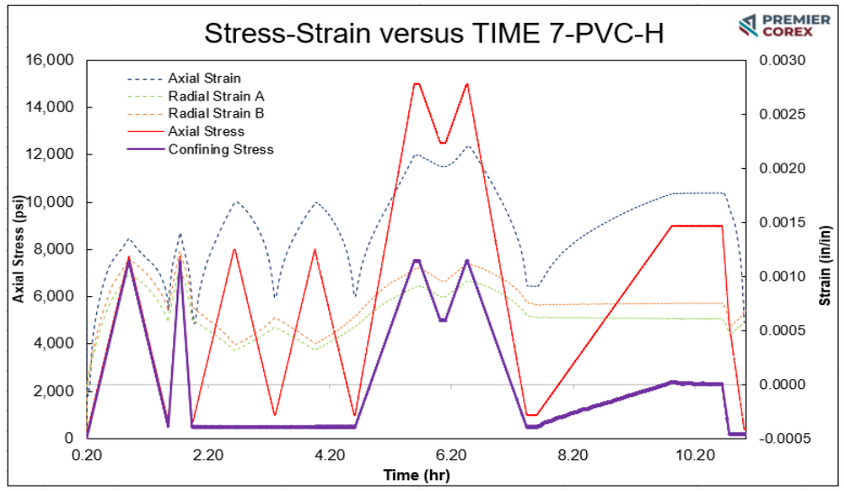
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

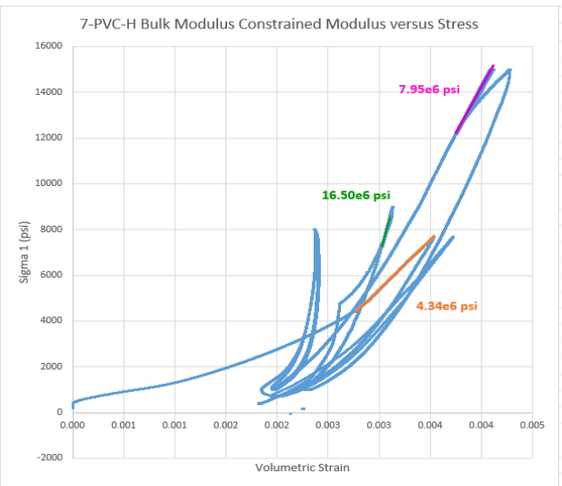
**Report Date:** 11/29/2023
**Project Number:** 23-0114

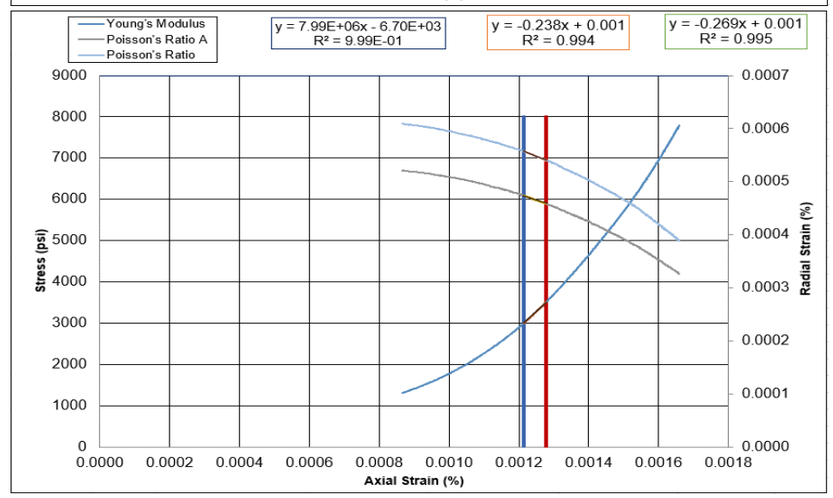


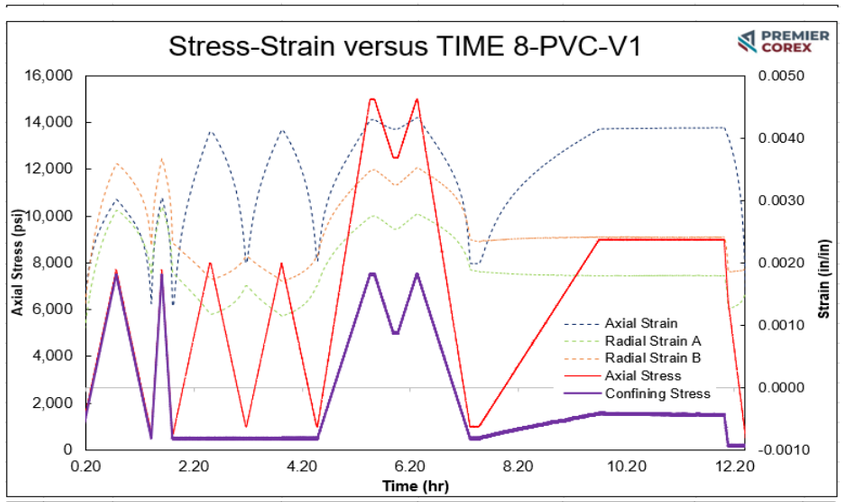



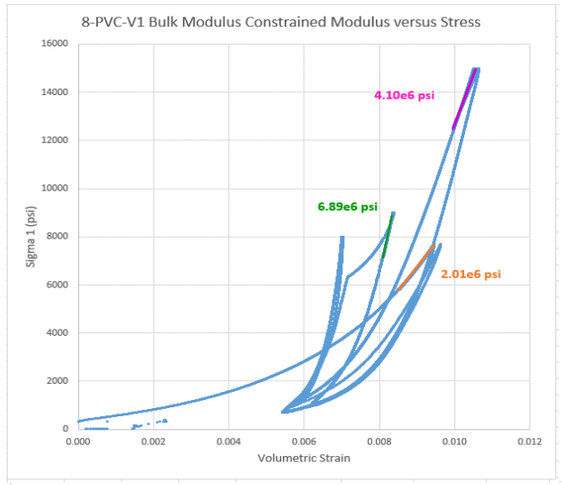
# Pore Volume Compressibility Plots

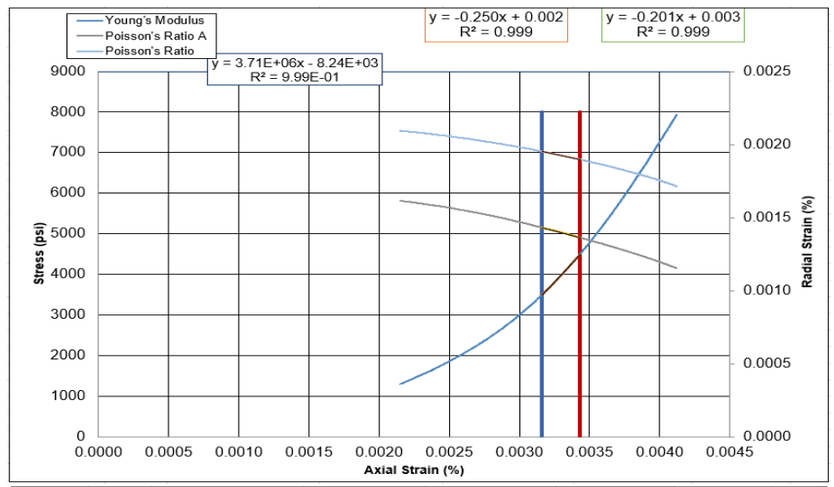
Conventional Core Plug Samples

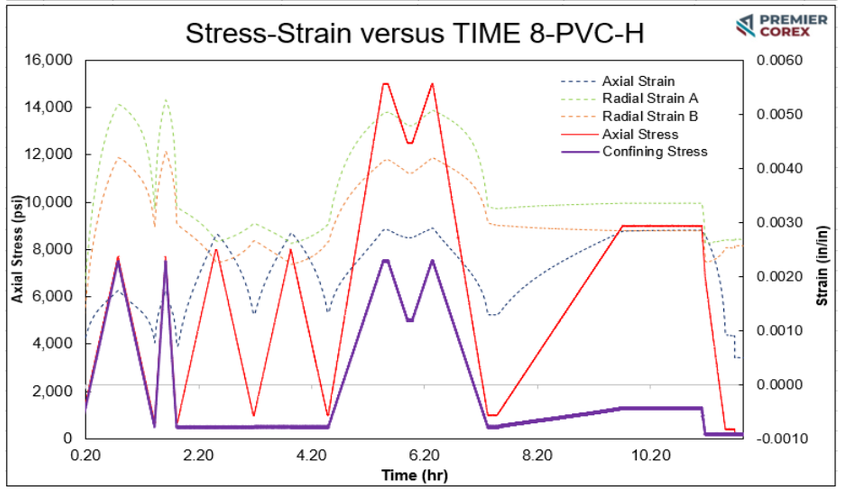
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

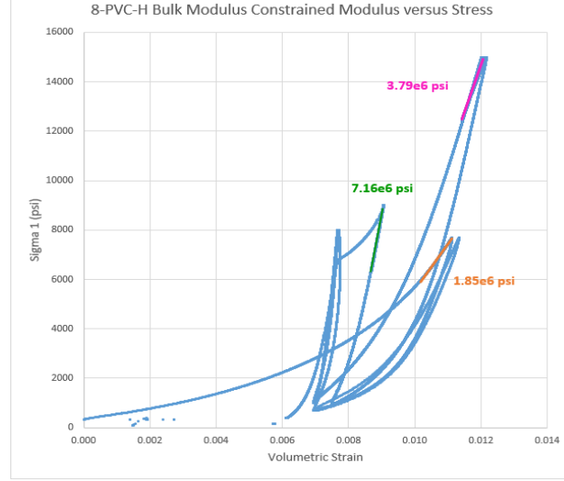
**Report Date:** 11/29/2023
**Project Number:** 23-0114

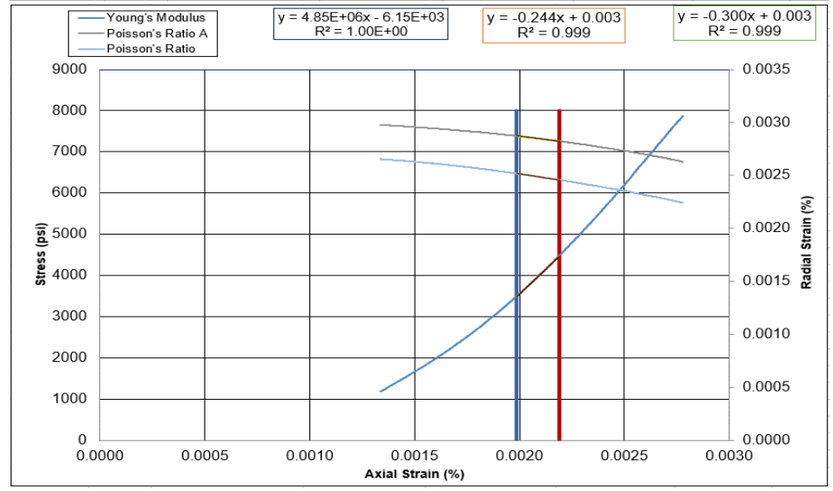


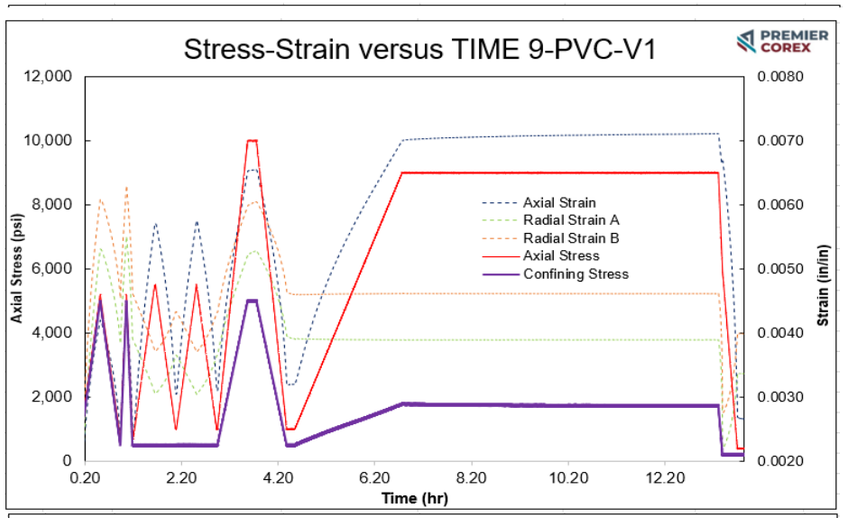



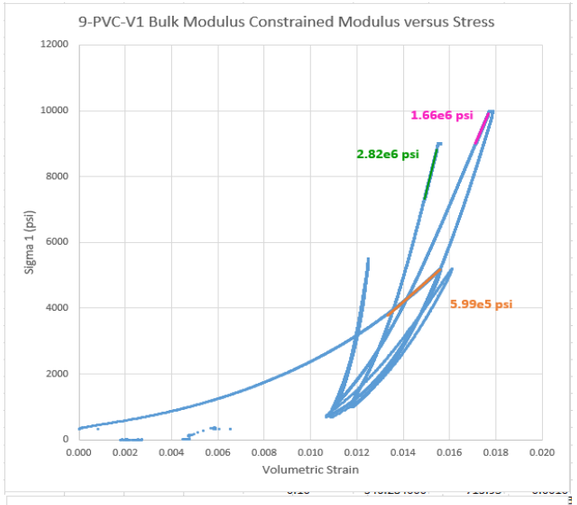
# Pore Volume Compressibility Plots

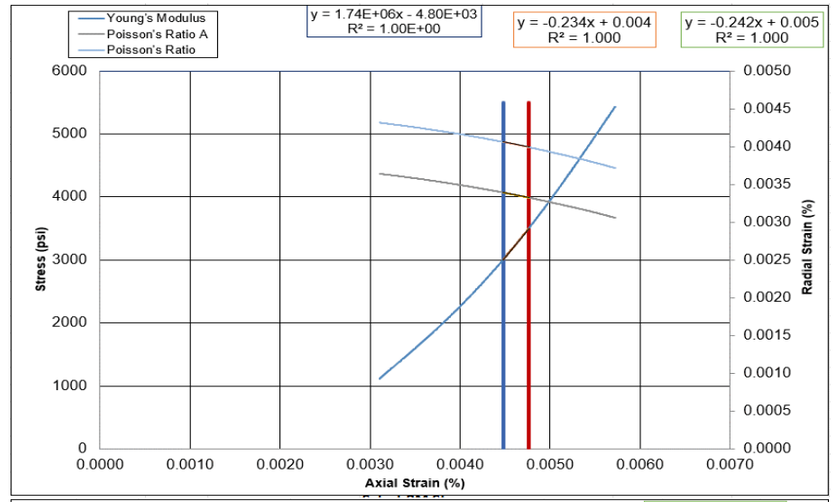
Conventional Core Plug Samples

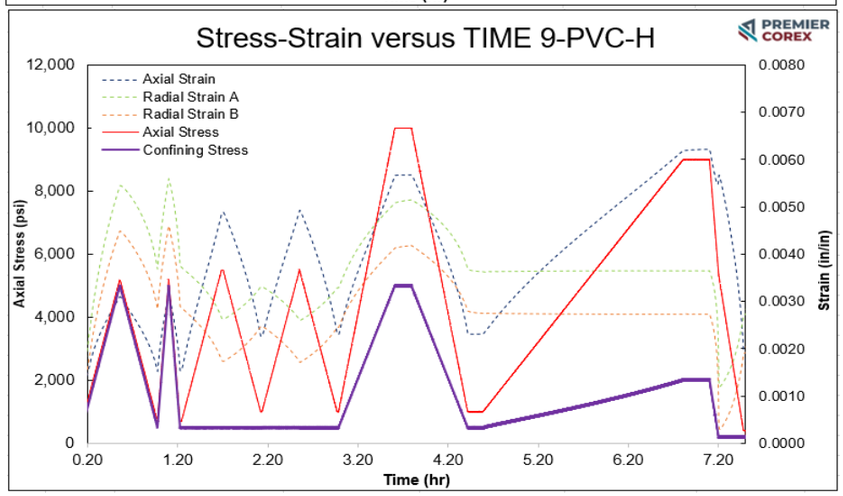
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

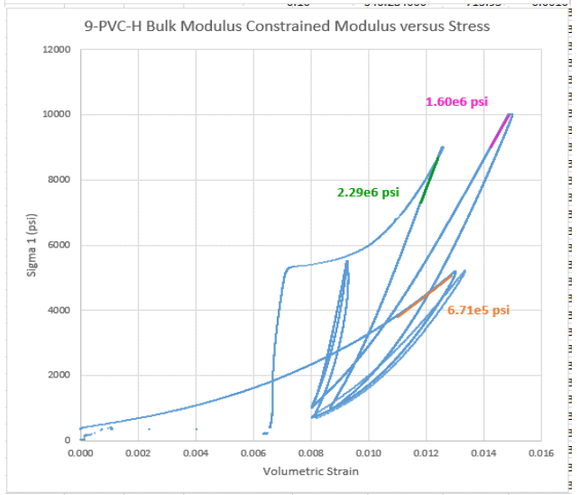
**Report Date:** 11/29/2023
**Project Number:** 23-0114

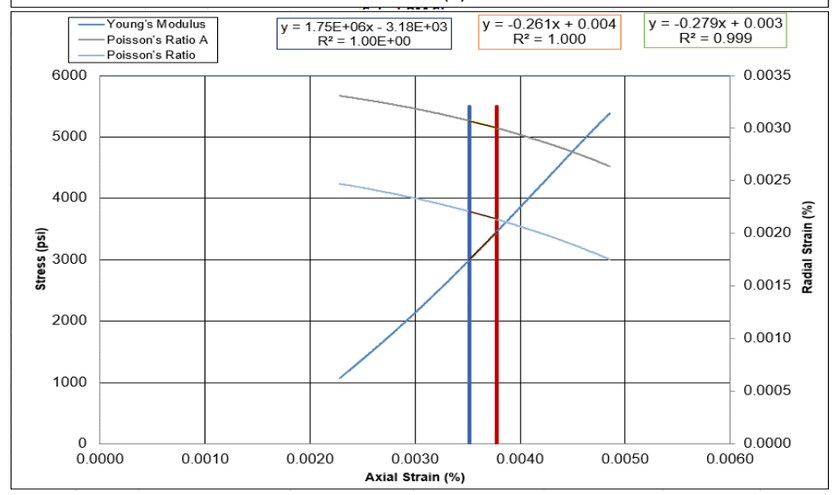


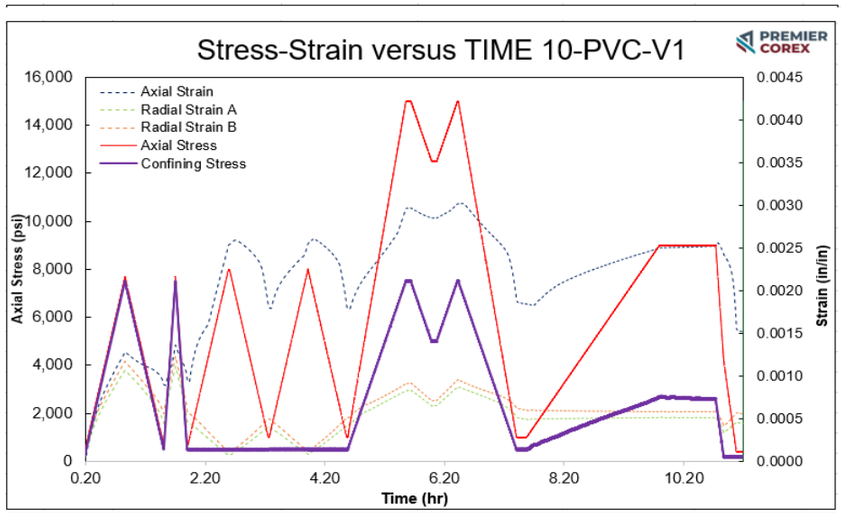



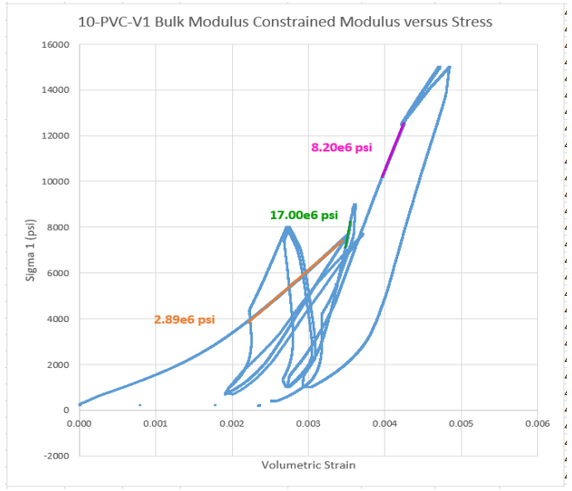
# Pore Volume Compressibility Plots

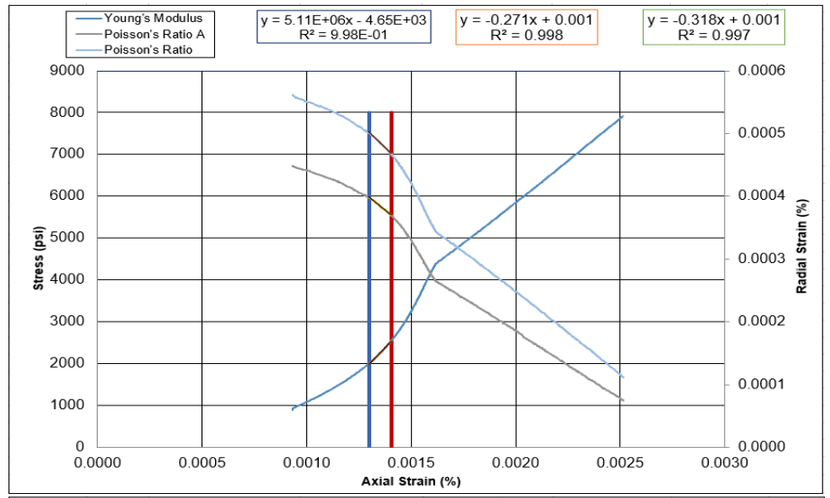
Conventional Core Plug Samples

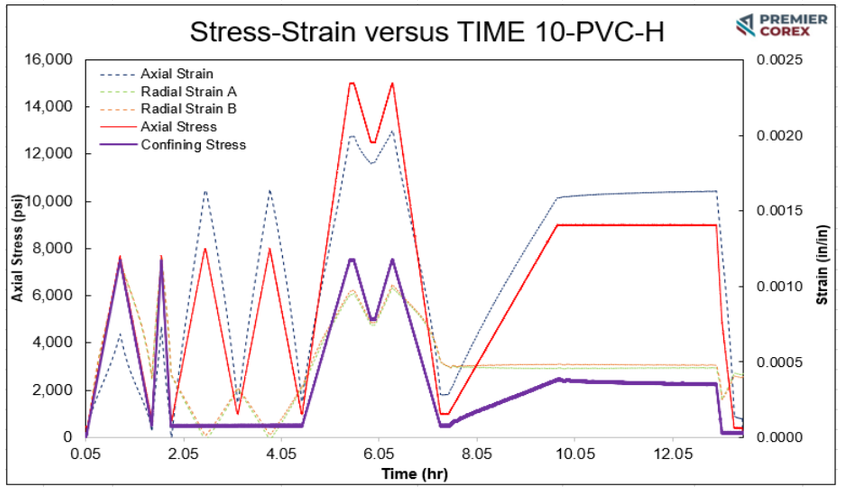
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

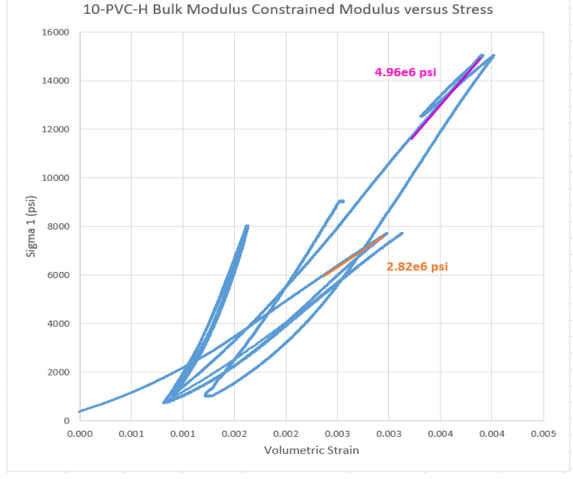
**Report Date:** 11/29/2023
**Project Number:** 23-0114

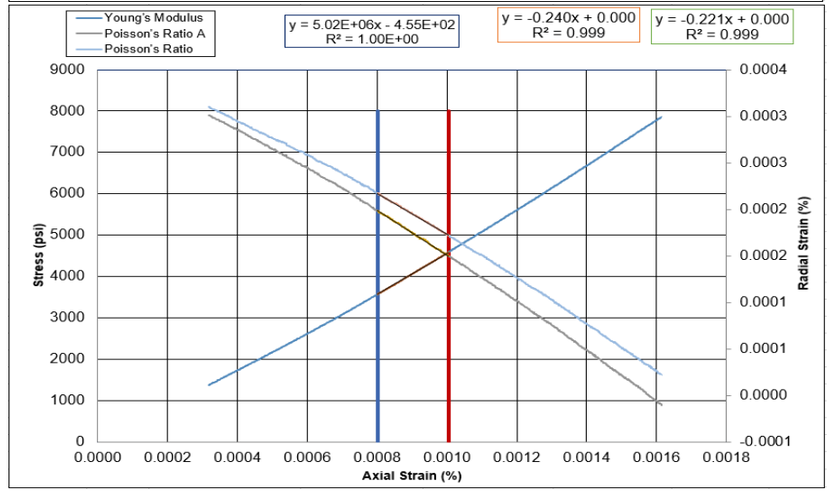


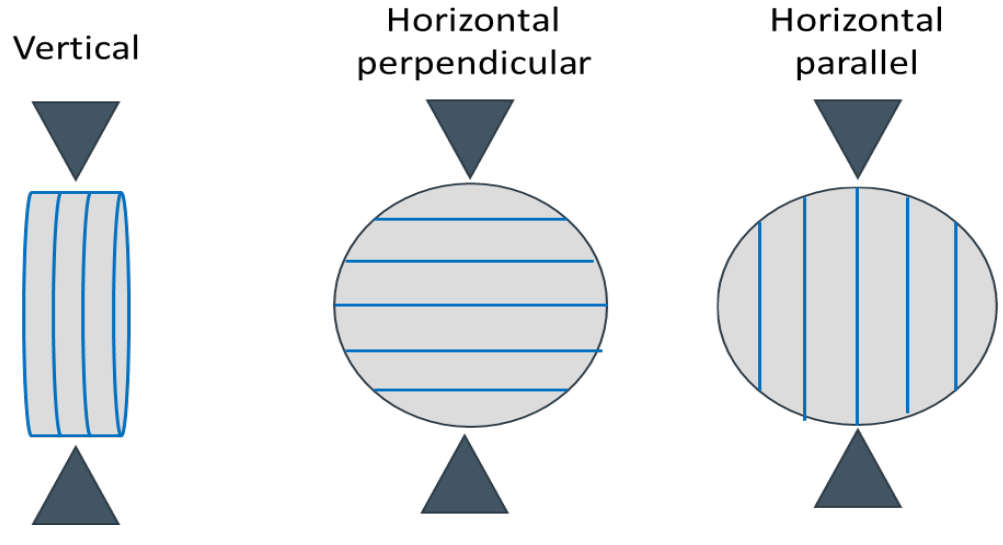
# GEOMECHANICAL REPORT - Brazil / Tensile Strength

Conventional Core Plug Samples

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114

| Formation Name | Sample ID | Core Depth (ft) | Sample Orientation | Orientation (to bedding) | Diameter (in) | Length (in) | L:D ratio | Weight (g) | Bulk Density (g/cc) | Maximum Load (lbf) | Tensile Strength (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Goose Egg | 4-BRZ-V | 8874.45 | Vertical | n/a | 1.01 | 0.51 | 0.50 | 19.78 | 2.93 | 669 | 824 |
| | 4-BRZ-H | 8874.35 | Horizontal | 0 | 1.01 | 0.55 | 0.54 | 21.08 | 2.91 | 1076 | 1233 |
| | 4-BRZ-H90 | 8875.35 | Horizontal | 90 | 1.01 | 0.50 | 0.49 | 19.17 | 2.94 | 530 | 673 |
| Minnektahta | 6-BRZ-V | 9030.23 | Vertical | n/a | 1.02 | 0.53 | 0.52 | 20.45 | 2.91 | 1152 | 1362 |
| | 6-BRZ-H2 | 9029.45 | Horizontal | 0 | 1.01 | 0.54 | 0.54 | 20.98 | 2.92 | 651 | 752 |
| | 6-BRZ-H90-2 | 9029.45 | Horizontal | 90 | 1.01 | 0.55 | 0.54 | 21.18 | 2.92 | 711 | 814 |
| Blaine | 7-BRZ-V | 9070.00 | Vertical | n/a | 1.00 | 0.52 | 0.52 | 19.92 | 2.94 | 1179 | 1428 |
| | 7-BRZ-H | 9070.00 | Horizontal | 0 | 1.00 | 0.53 | 0.52 | 19.85 | 2.93 | 461 | 558 |
| | 7-BRZ-H90 | 9070.23 | Horizontal | 90 | 1.00 | 0.49 | 0.49 | 18.32 | 2.94 | 681 | 894 |
| Flowerpot | 8-BRZ-V | 9110.00 | Vertical | n/a | 1.00 | 0.52 | 0.52 | 17.99 | 2.69 | 556 | 682 |
| | 8-BRZ-H | 9110.40 | Horizontal | 0 | 1.01 | 0.55 | 0.55 | 19.11 | 2.66 | 429 | 491 |
| | 8-BRZ-H90 | 9110.40 | Horizontal | 90 | 1.00 | 0.51 | 0.51 | 17.43 | 2.67 | 384 | 483 |
| Lyons | 9-BRZ-V | 9155.00 | Vertical | n/a | 1.00 | 0.53 | 0.53 | 13.62 | 2.01 | 222 | 268 |
| | 9-BRZ-H | 9155.25 | Horizontal | 0 | 1.02 | 0.55 | 0.54 | 14.34 | 1.97 | 114 | 130 |
| | 9-BRZ-H90 | 9155.25 | Horizontal | 90 | 1.01 | 0.52 | 0.52 | 13.98 | 2.06 | 323 | 393 |
| Satanka | 10-BRZ-V | 9184.45 | Vertical | n/a | 1.00 | 0.46 | 0.46 | 15.36 | 2.58 | 1368 | 1880 |
| | 10-BRZ-H | 9184.35 | Horizontal | 0 | 1.00 | 0.58 | 0.58 | 19.25 | 2.58 | 1407 | 1550 |
| | 10-BRZ-H90-2 | 9184.45 | Horizontal | 90 | 1.00 | 0.54 | 0.54 | 18.00 | 2.61 | 1202 | 1426 |



# GEOMECHANICAL REPORT - Fracture Toughness

Conventional Core Plug Samples

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114

| Formation Name | Sample ID | Core Depth (ft) | Sample Orientation | Orientation (to bedding) | Diameter (in) | Length (in) | Notch Length (in) | L:D ratio | Weight (g) | Bulk Density (g/cc) | Maximum Load (lbf) | Fracture Toughness ($psi.in^{0.5}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lyons | 9-FT-H | 9155.25 | Horizontal | n/a | 1.00 | 0.55 | 0.14 | 0.55 | 16.25 | 2.30 | 18 | 103 |

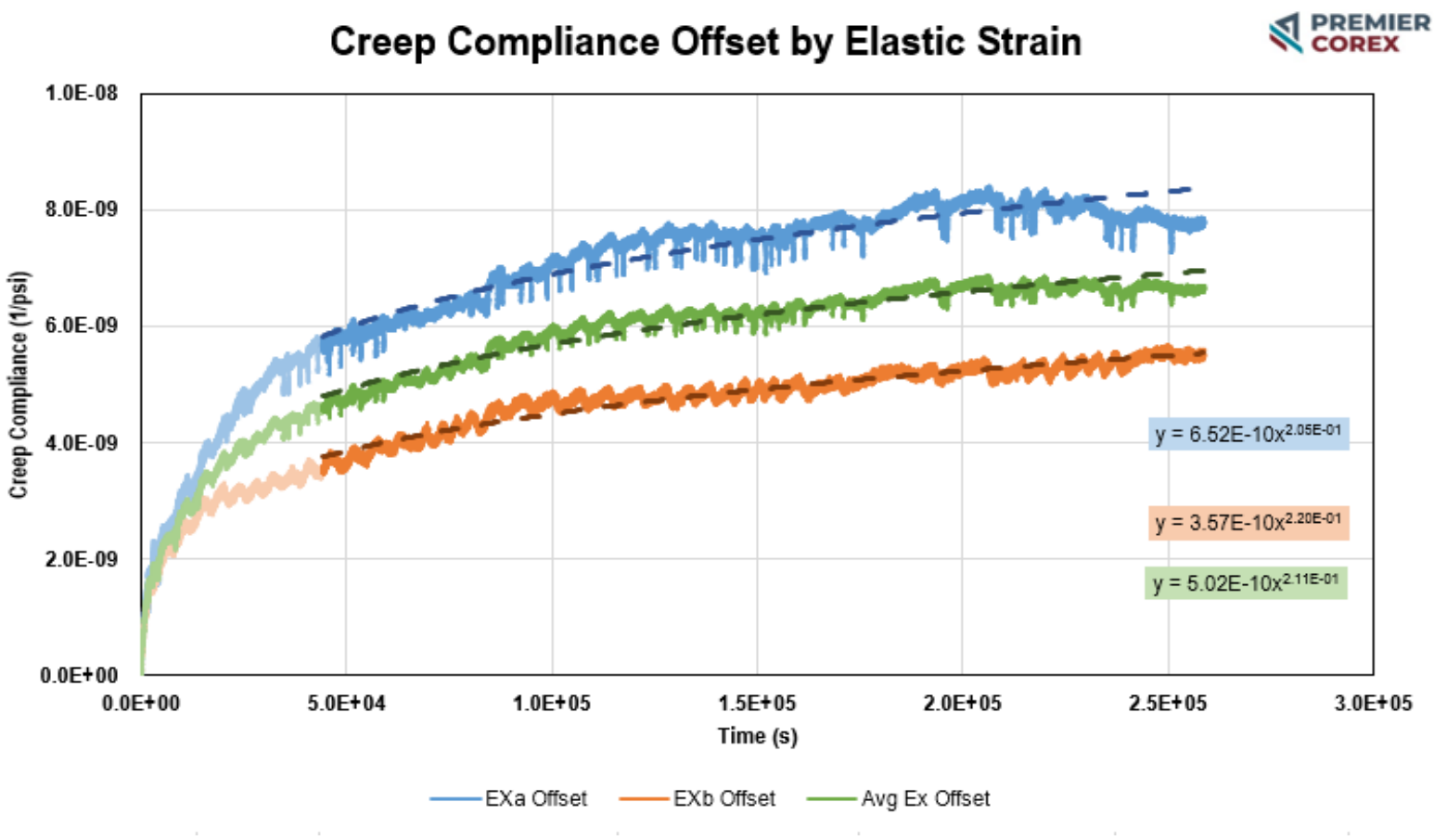
# GEOMECHANICAL REPORT - Creep Test

Conventional Core Plug Samples

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114

| Formation Name | Sample ID | Core Depth (ft) | Sample Orientation | L:D ratio | Bulk Density (g/cc) | Confining Stress (psi) | Differential Stress (psi) | Constant B ($psi^{-1}$) | Constant n |
|---|---|---|---|---|---|---|---|---|---|
| Blaine | 7-CRP-V | 9070.80 | Vertical | 1.63 | 2.77 | 7500 | 12000 | 5.02E-10 | 0.211 |




Note: Analysis of test data was performed using following equation:

$$J = \frac{\varepsilon}{\sigma} = Bt^n$$

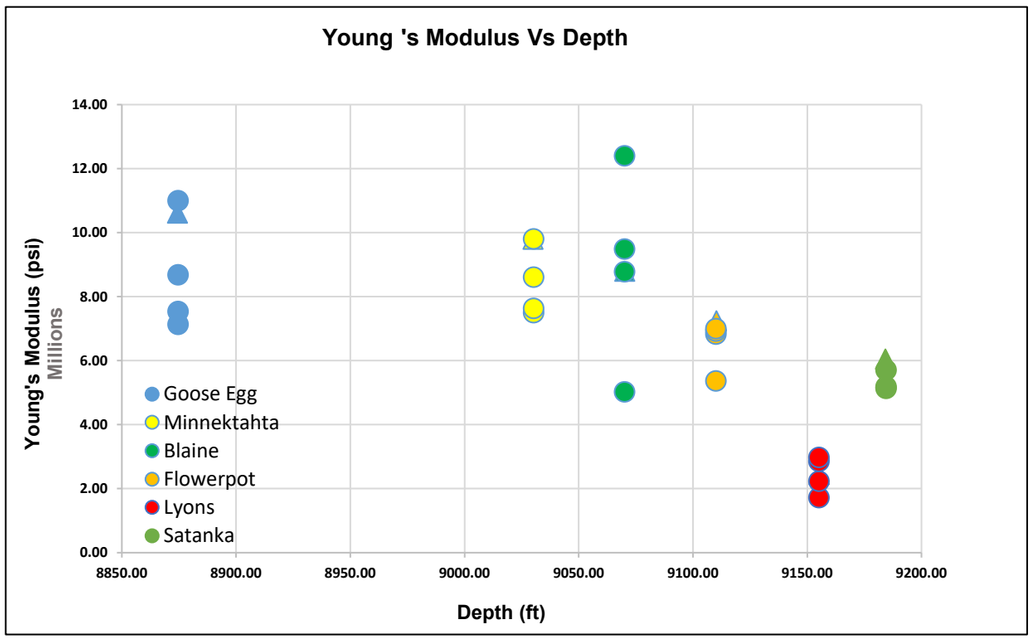
where J is creep compliance factor, ε and σ are axial strain and applied differential stress, t is time and B and N are two emprical constants in the Power Law creep model.
Source: *Sone, H. and Zoback, M. 2014. Time-dependent deformation of shale gas reservoir rocks and its long-term effect on the in situ state of stress. International Journal of Rock Mechanics & Mining Sciences 69 (2014) 120–132.*

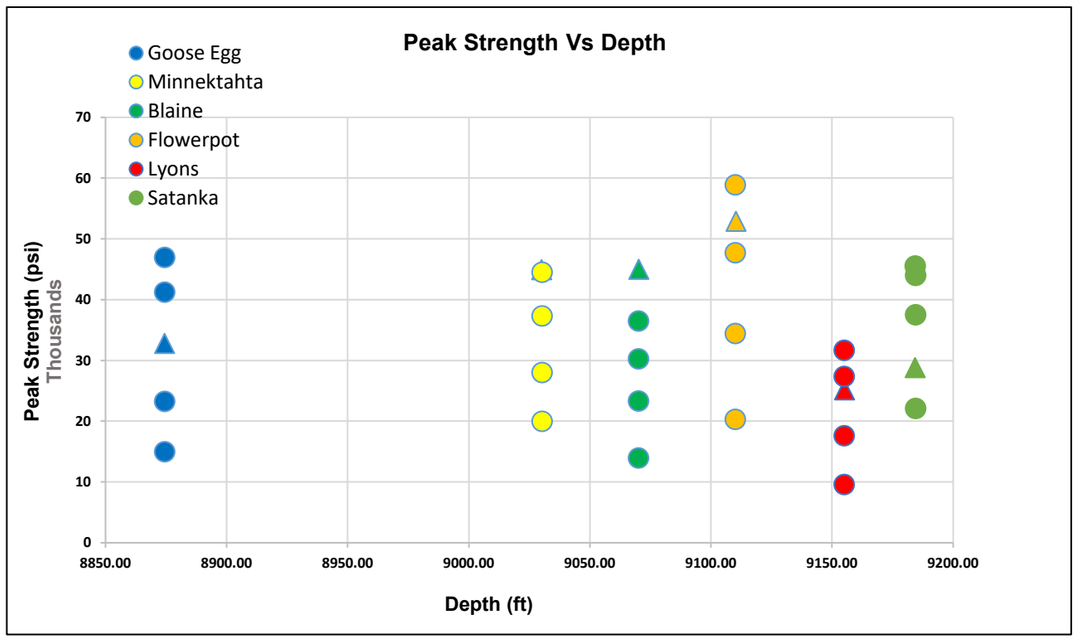
# GEOMECHANICAL REPORT - Composite Plots

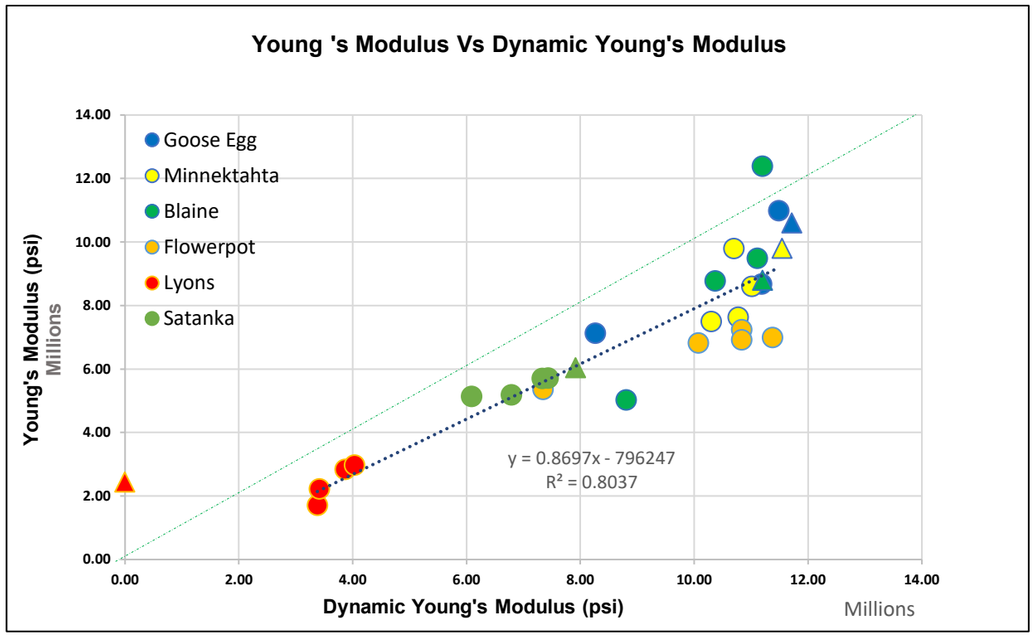
Conventional Core Plug Samples
TXC, Brazil, PVC

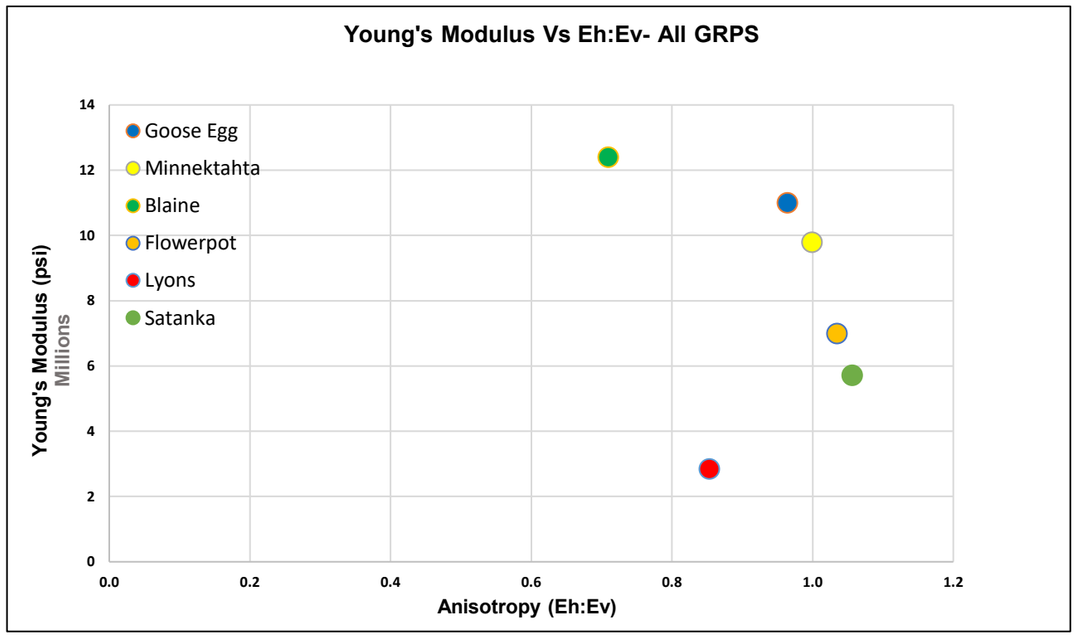
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114



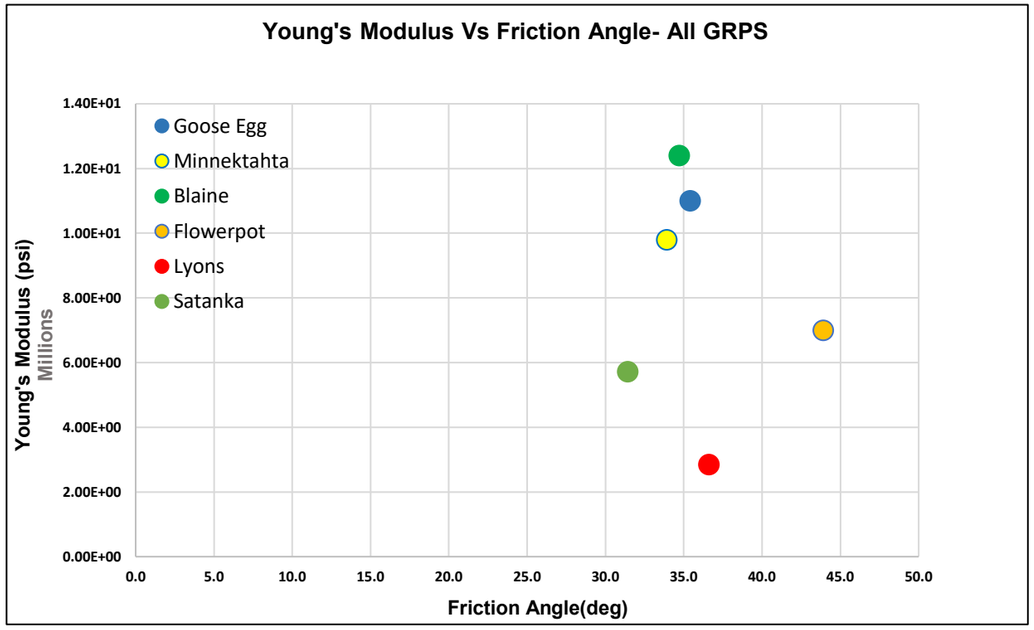



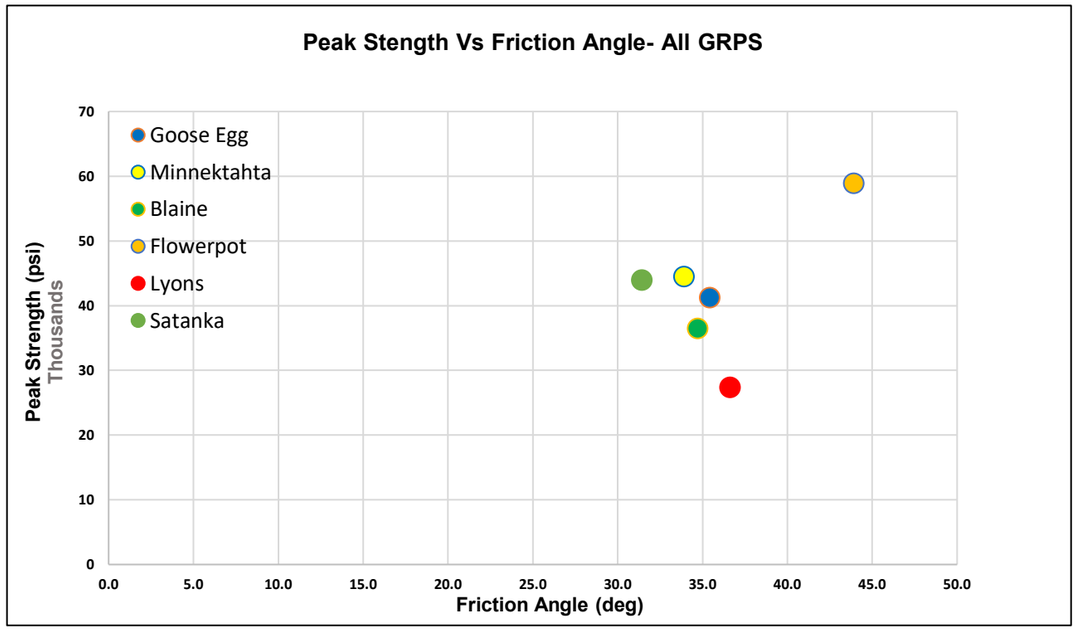
# GEOMECHANICAL REPORT - Composite Plots

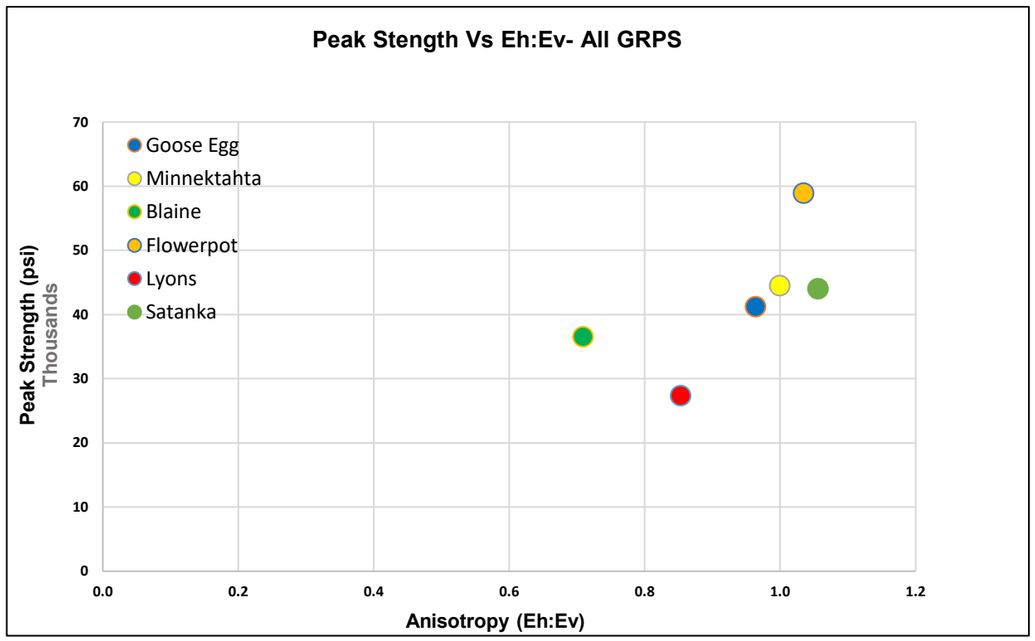
Conventional Core Plug Samples
TXC, Brazil, PVC

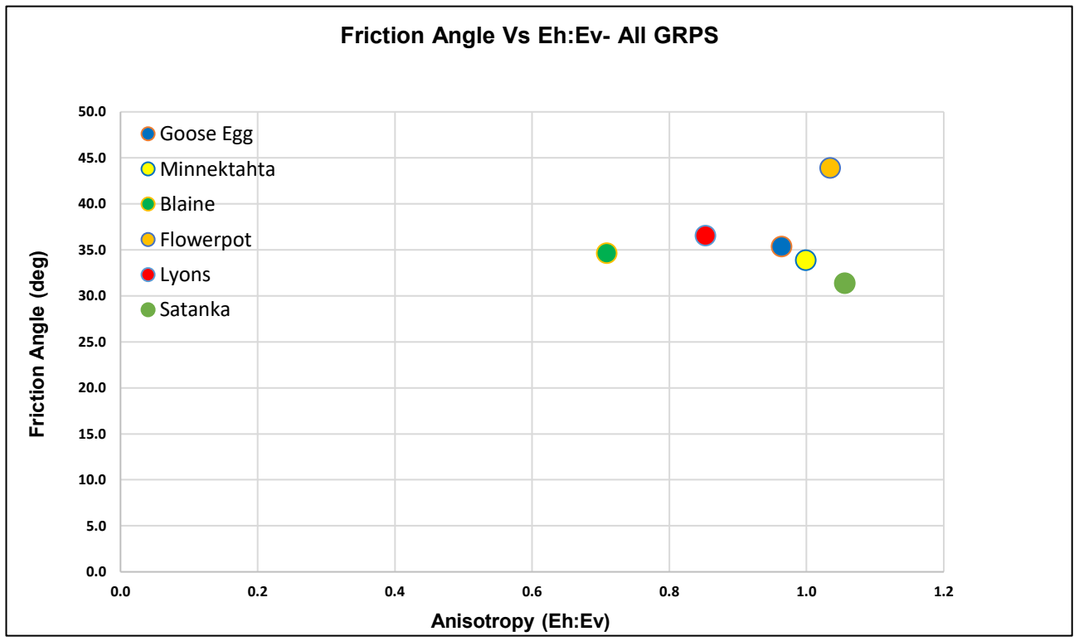
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114



# GEOMECHANICAL REPORT - Composite Plots

Conventional Core Plug Samples
TXC, Brazil, PVC

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
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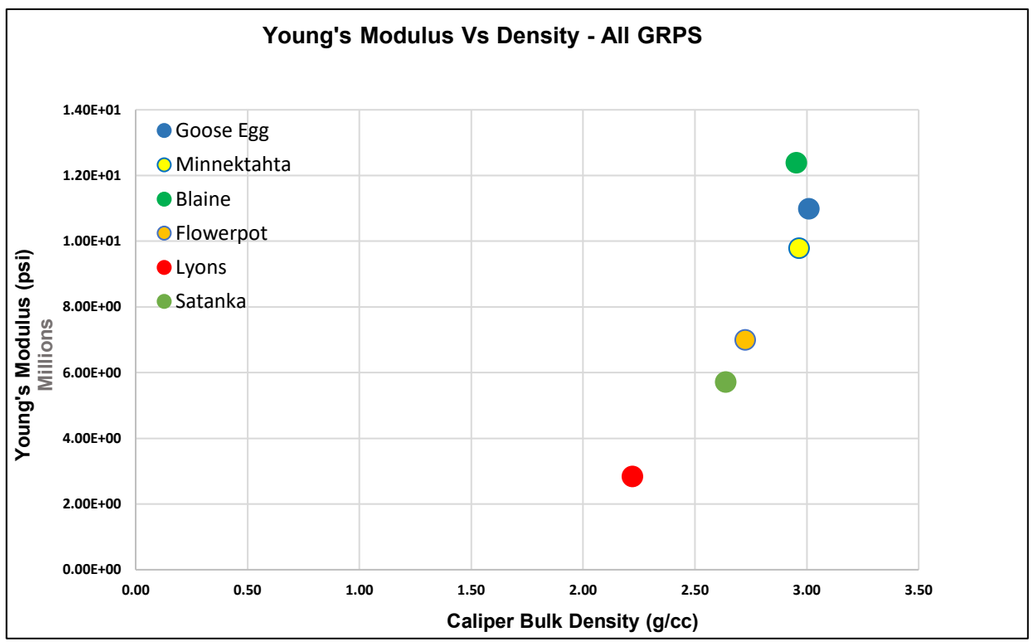


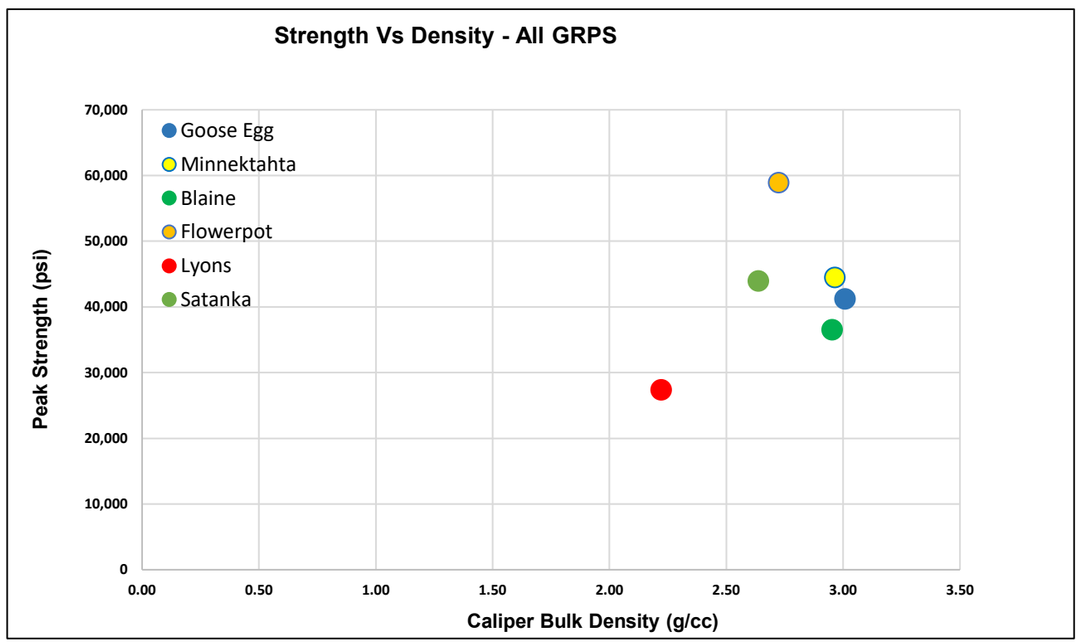


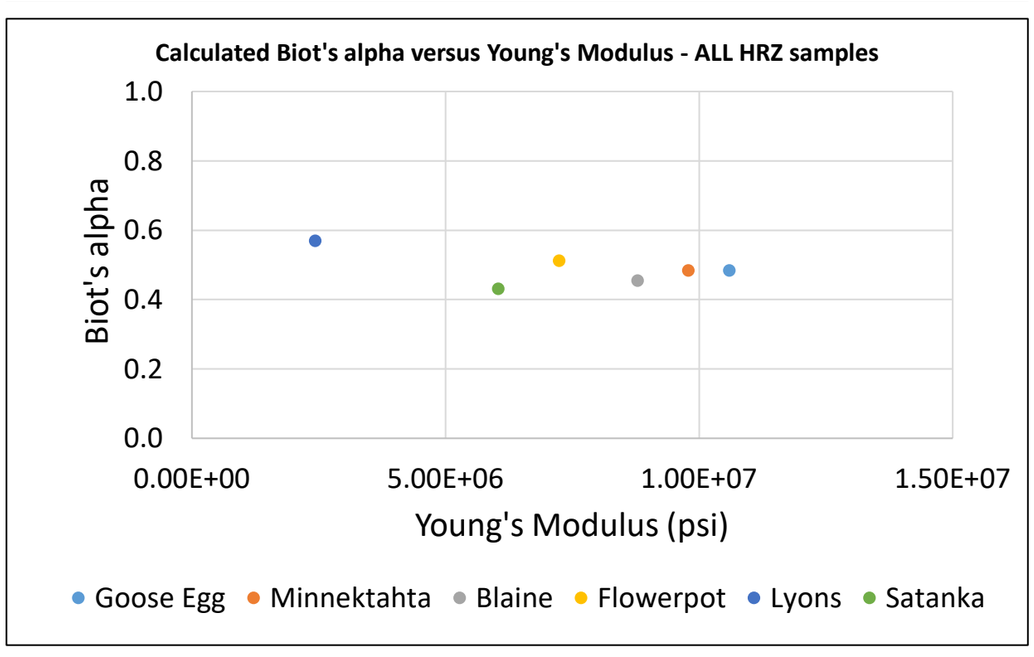


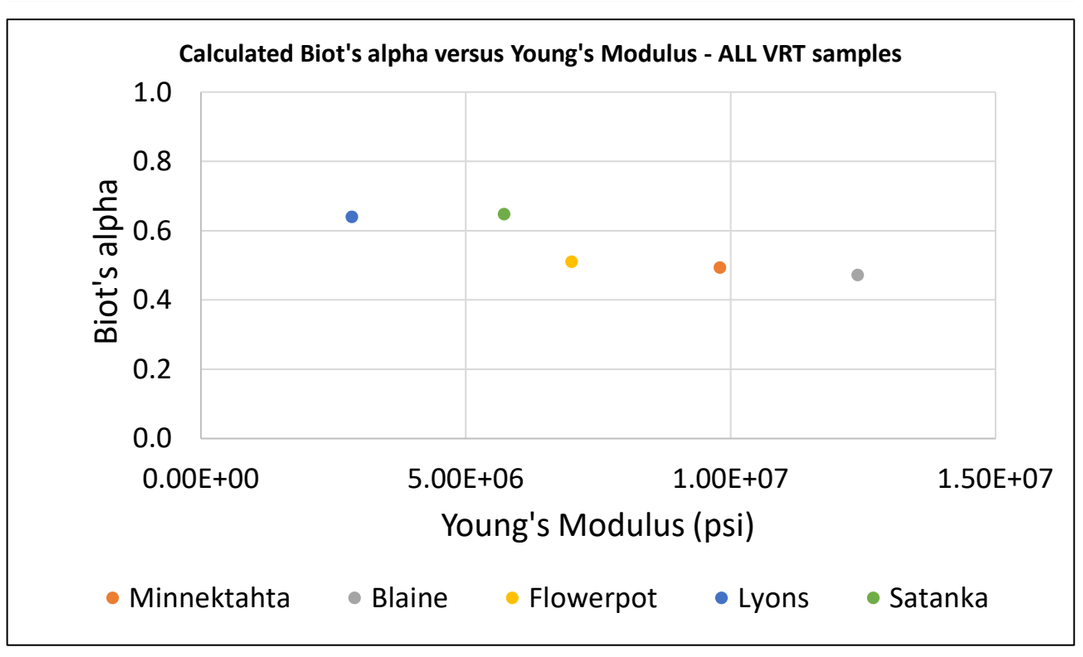

# GEOMECHANICAL REPORT - Composite Plots

Conventional Core Plug Samples
TXC, Brazil, PVC

**Client:** Devon Energy LLC
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**Location:** Laramie County, Wyoming

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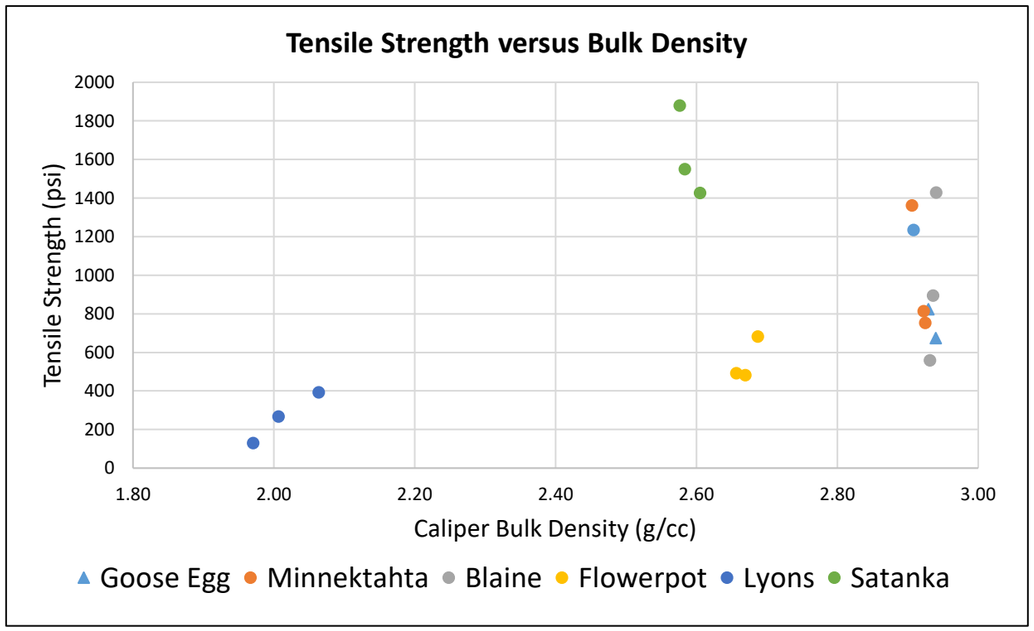
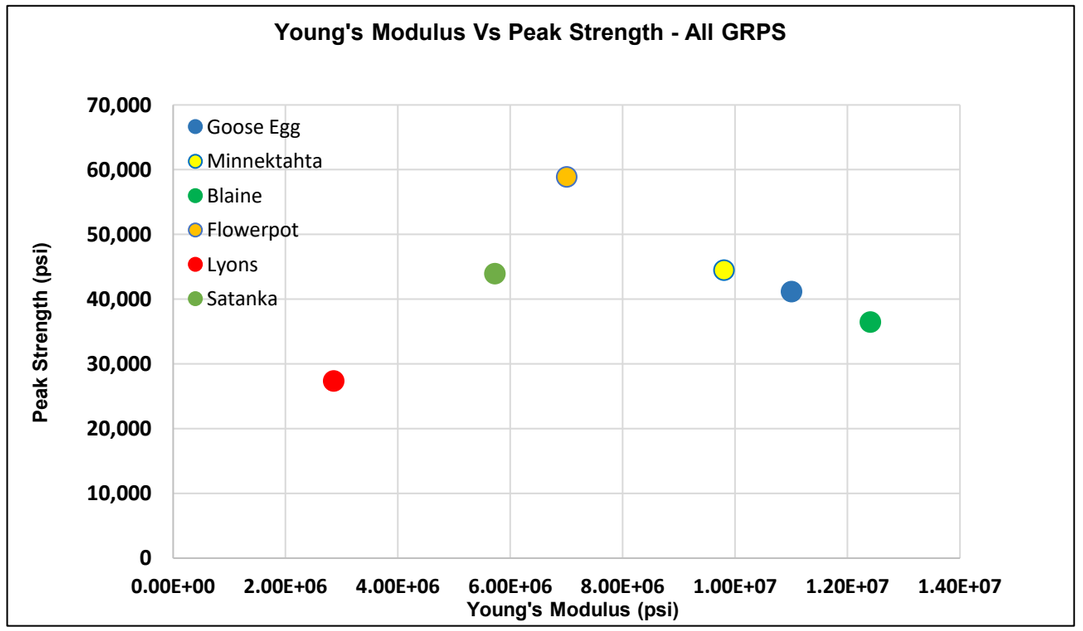


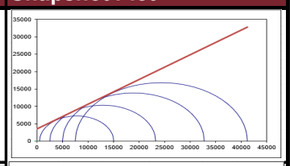
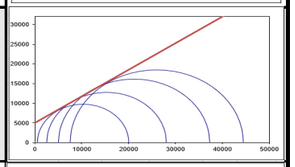
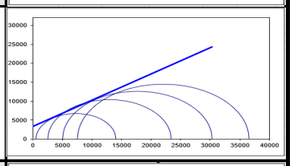
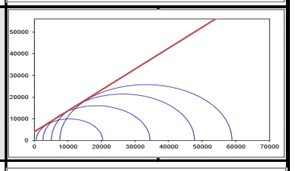
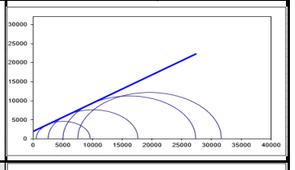
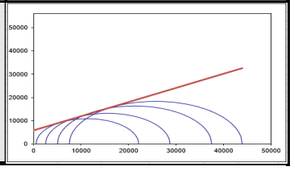



# GEOMECHANICAL REPORT - Static Properties

Conventional Core Plug Samples
Triaxial Compressive Strength

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114

| | | | | | | | | | | Anisotropy | | Mohr Columb | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Formation Name | Sample ID | Core Depth (ft) | Sample Orientation | Confining Stress (psi) | Peak Strength (psi) | YM (psi) | Dynamic YM (psi) | PR-0° negative | PR-90° negative | Elasticity Eh:Ev | Strength Peak h: Peak v | Friction Angle | Cohesion | Snapshot Plot |
| Goose Egg | 4-TXC-H | 8874.35 | Horizontal | 7500 | 46989 | 1.06E+07 | 1.17E+07 | 0.296 | 0.305 | 1.0 | 1.1 | 35.4 | 3499 |  |
| | 4-TXC-V1 | 8874.45 | Vertical | 500 | 15031 | 7.14E+06 | 8.26E+06 | 0.228 | 0.310 | | | | | |
| | 4-TXC-V2 | 8874.45 | Vertical | 2500 | 23268 | 7.54E+06 | 1.03E+07 | 0.296 | 0.335 | | | | | |
| | 4-TXC-V3 | 8874.45 | Vertical | 5000 | 32796 | 8.68E+06 | 1.12E+07 | 0.336 | 0.353 | | | | | |
| | 4-TXC-V4 | 8874.45 | Vertical | 7500 | 41251 | 1.10E+07 | 1.15E+07 | 0.309 | 0.363 | | | | | |
| Minnektahta | 6-TXC-H | 9030.13 | Horizontal | 7500 | 44909 | 9.79E+06 | 1.15E+07 | 0.277 | 0.296 | 1.0 | 1.0 | 33.9 | 5019 |  |
| | 6-TXC-V1 | 9030.23 | Vertical | 500 | 20044 | 7.50E+06 | 1.03E+07 | 0.232 | 0.274 | | | | | |
| | 6-TXC-V2 | 9030.23 | Vertical | 2500 | 28079 | 7.64E+06 | 1.08E+07 | 0.205 | 0.253 | | | | | |
| | 6-TXC-V3 | 9030.23 | Vertical | 5000 | 37341 | 8.61E+06 | 1.10E+07 | 0.274 | 0.349 | | | | | |
| | 6-TXC-V4 | 9030.23 | Vertical | 7500 | 44529 | 9.80E+06 | 1.07E+07 | 0.259 | 0.255 | | | | | |
| Blaine | 7-TXC-H | 9070.23 | Horizontal | 7500 | 44949 | 8.79E+06 | 1.12E+07 | 0.413 | 0.356 | 0.7 | 1.2 | 34.7 | 3362 |  |
| | 7-TXC-V1 | 9070.00 | Vertical | 500 | 14019 | 5.03E+06 | 8.80E+06 | 0.128 | 0.177 | | | | | |
| | 7-TXC-V2 | 9070.00 | Vertical | 2500 | 23366 | 8.78E+06 | 1.04E+07 | 0.257 | 0.311 | | | | | |
| | 7-TXC-V3 | 9070.00 | Vertical | 5000 | 30292 | 9.49E+06 | 1.11E+07 | 0.329 | 0.335 | | | | | |
| | 7-TXC-V4 | 9070.00 | Vertical | 7500 | 36539 | 1.24E+07 | 1.12E+07 | 0.337 | 0.414 | | | | | |
| Flowerpot | 8-TXC-H | 9110.40 | Horizontal | 7500 | 52876 | 7.24E+06 | 1.08E+07 | 0.282 | 0.299 | 1.0 | 0.9 | 43.9 | 4053 |  |
| | 8-TXC-V1 | 9110.00 | Vertical | 500 | 20350 | 5.37E+06 | 7.34E+06 | 0.376 | 0.364 | | | | | |
| | 8-TXC-V2 | 9110.00 | Vertical | 2500 | 34486 | 6.83E+06 | 1.01E+07 | 0.232 | 0.252 | | | | | |
| | 8-TXC-V3 | 9110.00 | Vertical | 5000 | 47771 | 6.93E+06 | 1.08E+07 | 0.289 | 0.299 | | | | | |
| | 8-TXC-V4 | 9110.00 | Vertical | 7500 | 58949 | 7.00E+06 | 1.14E+07 | 0.249 | 0.289 | | | | | |
| Lyons | 9-TXC-H | 9155.25 | Horizontal | 5000 | 25157 | 2.43E+06 | | 0.127 | 0.122 | 0.9 | 0.9 | 36.6 | 1936 |  |
| | 9-TXC-V1 | 9155.00 | Vertical | 500 | 9615 | 1.72E+06 | 3.38E+06 | 0.190 | 0.253 | | | | | |
| | 9-TXC-V2 | 9155.00 | Vertical | 2500 | 17662 | 2.23E+06 | 3.41E+06 | 0.141 | 0.158 | | | | | |
| | 9-TXC-V3 | 9155.00 | Vertical | 5000 | 27395 | 2.85E+06 | 3.86E+06 | 0.129 | 0.152 | | | | | |
| | 9-TXC-V4 | 9155.00 | Vertical | 7500 | 31720 | 2.98E+06 | 4.03E+06 | 0.140 | 0.180 | | | | | |
| Satanka | 10-TXC-H | 9184.35 | Horizontal | 7500 | 45585 | 6.04E+06 | 7.92E+06 | 0.160 | 0.226 | 1.1 | 1.0 | 31.4 | 5852 |  |
| | 10-TXC-V1 | 9184.45 | Vertical | 500 | 22152 | 5.14E+06 | 6.09E+06 | 0.171 | 0.173 | | | | | |
| | 10-TXC-V2 | 9184.45 | Vertical | 2500 | 28762 | 5.19E+06 | 6.78E+06 | 0.164 | 0.227 | | | | | |
| | 10-TXC-V3 | 9184.45 | Vertical | 5000 | 37547 | 5.71E+06 | 7.33E+06 | 0.183 | 0.190 | | | | | |
| | 10-TXC-V4 | 9184.45 | Vertical | 7500 | 44012 | 5.72E+06 | 7.43E+06 | 0.212 | 0.187 | | | | | |

Notes: Blacked out cells indicates no data was collected and/or presented
Red font indicates data that was considered an outlier
For MCFE: Blue line indicates the failure envelope used data from all four samples while red line indicates failure envelope used only the three lower confining pressure samples

# GEOMECHANICAL REPORT - Dynamic Properties

Conventional Core Plug Samples
Triaxial Compressive Strength

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

**Report Date:** 11/29/2023
**Project Number:** 23-0114

| Formation Name | Sample ID | Core Depth (ft) | Sample Orientation | Confining Stress (psi) | Peak Strength (psi) | Vp | Vs | Vp:Vs (ratio) | Vs2 | Vp:Vs2 (ratio) | Vs:Vs2 (ratio) | E1 (psi) | E2 (psi) | μ1 | μ2 | G1 (psi) | G2 (psi) | K1 (psi) | K2 (psi) | Lames 1 | Lames 2 | M psi | approx 1/2 Peak (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Goose Egg | 4-TXC-H | 8874.35 | Horizontal | 7500 | 46989 | 19081 | 10838 | 1.76 | 10841 | 1.76 | 1.00 | 1.17E+07 | 1.17E+07 | 0.262 | 0.262 | 4.64E+06 | 4.64E+06 | 1.02E+07 | 1.02E+07 | 1.44E+07 | 5.10E+06 | 1.44E+07 | 23495 |
| | 4-TXC-V1 | 8874.45 | Vertical | 500 | 15031 | 15613 | 9061 | 1.72 | 9262 | 1.69 | 0.98 | 8.13E+06 | 8.38E+06 | 0.246 | 0.228 | 3.26E+06 | 3.41E+06 | 6.68E+06 | 6.43E+06 | 9.69E+06 | 2.87E+06 | 9.69E+06 | 7516 |
| | 4-TXC-V2 | 8874.45 | Vertical | 2500 | 23268 | 18011 | 10114 | 1.78 | 10154 | 1.77 | 1.00 | 1.03E+07 | 1.03E+07 | 0.270 | 0.267 | 4.04E+06 | 4.08E+06 | 9.29E+06 | 9.24E+06 | 1.28E+07 | 4.67E+06 | 1.28E+07 | 11634 |
| | 4-TXC-V3 | 8874.45 | Vertical | 5000 | 32796 | 18794 | 10483 | 1.79 | 10536 | 1.78 | 0.99 | 1.11E+07 | 1.12E+07 | 0.274 | 0.271 | 4.37E+06 | 4.42E+06 | 1.03E+07 | 1.02E+07 | 1.41E+07 | 5.22E+06 | 1.41E+07 | 16398 |
| | 4-TXC-V4 | 8874.45 | Vertical | 7500 | 41251 | 18952 | 10551 | 1.80 | 10683 | 1.77 | 0.99 | 1.14E+07 | 1.16E+07 | 0.275 | 0.267 | 4.46E+06 | 4.57E+06 | 1.04E+07 | 1.03E+07 | 1.44E+07 | 5.24E+06 | 1.44E+07 | 20625 |
| Minnektahta | 6-TXC-H | 9030.13 | Horizontal | 7500 | 44909 | 19119 | 11032 | 1.73 | 10876 | 1.76 | 1.01 | 1.17E+07 | 1.14E+07 | 0.250 | 0.261 | 4.66E+06 | 4.53E+06 | 9.82E+06 | 1.00E+07 | 1.40E+07 | 4.94E+06 | 1.40E+07 | 22454 |
| | 6-TXC-V1 | 9030.23 | Vertical | 500 | 20044 | 17758 | 10168 | 1.75 | 10209 | 1.74 | 1.00 | 1.03E+07 | 1.03E+07 | 0.256 | 0.253 | 4.09E+06 | 4.12E+06 | 8.72E+06 | 8.66E+06 | 1.25E+07 | 4.22E+06 | 1.25E+07 | 10022 |
| | 6-TXC-V2 | 9030.23 | Vertical | 2500 | 28079 | 18169 | 10433 | 1.74 | 10523 | 1.73 | 0.99 | 1.07E+07 | 1.08E+07 | 0.254 | 0.248 | 4.27E+06 | 4.34E+06 | 9.06E+06 | 8.93E+06 | 1.29E+07 | 4.26E+06 | 1.29E+07 | 14039 |
| | 6-TXC-V3 | 9030.23 | Vertical | 5000 | 37341 | 18240 | 10454 | 1.74 | 10528 | 1.73 | 0.99 | 1.10E+07 | 1.11E+07 | 0.255 | 0.250 | 4.36E+06 | 4.42E+06 | 9.27E+06 | 9.16E+06 | 1.33E+07 | 4.43E+06 | 1.33E+07 | 18671 |
| | 6-TXC-V4 | 9030.23 | Vertical | 7500 | 44529 | 19044 | 10642 | 1.79 | 10757 | 1.77 | 0.99 | 1.06E+07 | 1.08E+07 | 0.273 | 0.266 | 4.17E+06 | 4.26E+06 | 9.73E+06 | 9.58E+06 | 1.33E+07 | 4.83E+06 | 1.33E+07 | 22265 |
| Blaine | 7-TXC-H | 9070.23 | Horizontal | 7500 | 44949 | 19046 | 10097 | 1.89 | 10884 | 1.75 | 0.93 | 1.06E+07 | 1.18E+07 | 0.305 | 0.258 | 4.05E+06 | 4.71E+06 | 1.13E+07 | 1.02E+07 | 1.44E+07 | 5.00E+06 | 1.44E+07 | 22474 |
| | 7-TXC-V1 | 9070.00 | Vertical | 500 | 14019 | 16161 | 9805 | 1.65 | 9195 | 1.76 | 1.07 | 9.18E+06 | 8.42E+06 | 0.209 | 0.261 | 3.80E+06 | 3.34E+06 | 6.57E+06 | 7.33E+06 | 1.03E+07 | 3.64E+06 | 1.03E+07 | 7010 |
| | 7-TXC-V2 | 9070.00 | Vertical | 2500 | 23366 | 18608 | 10169 | 1.83 | 10122 | 1.84 | 1.00 | 1.04E+07 | 1.03E+07 | 0.287 | 0.290 | 4.04E+06 | 4.00E+06 | 1.02E+07 | 1.02E+07 | 1.35E+07 | 5.52E+06 | 1.35E+07 | 11683 |
| | 7-TXC-V3 | 9070.00 | Vertical | 5000 | 30292 | 18963 | 10526 | 1.80 | 10405 | 1.82 | 1.01 | 1.12E+07 | 1.10E+07 | 0.277 | 0.285 | 4.38E+06 | 4.28E+06 | 1.05E+07 | 1.06E+07 | 1.42E+07 | 5.66E+06 | 1.42E+07 | 15146 |
| | 7-TXC-V4 | 9070.00 | Vertical | 7500 | 36539 | 19063 | 10466 | 1.82 | 10452 | 1.82 | 1.00 | 1.12E+07 | 1.12E+07 | 0.284 | 0.285 | 4.36E+06 | 4.35E+06 | 1.08E+07 | 1.08E+07 | 1.45E+07 | 5.77E+06 | 1.45E+07 | 18270 |
| Flowerpot | 8-TXC-H | 9110.40 | Horizontal | 7500 | 52876 | 17667 | 11446 | 1.54 | 11325 | 1.56 | 1.01 | 1.09E+07 | 1.08E+07 | 0.138 | 0.151 | 4.78E+06 | 4.68E+06 | 6.23E+06 | 6.40E+06 | 1.14E+07 | 2.03E+06 | 1.14E+07 | 26438 |
| | 8-TXC-V1 | 9110.00 | Vertical | 500 | 20350 | 15343 | 9220 | 1.66 | 8929 | 1.72 | 1.03 | 7.50E+06 | 7.19E+06 | 0.217 | 0.244 | 3.08E+06 | 2.89E+06 | 5.57E+06 | 5.89E+06 | 8.53E+06 | 2.75E+06 | 8.53E+06 | 10175 |
| | 8-TXC-V2 | 9110.00 | Vertical | 2500 | 34486 | 17333 | 10256 | 1.69 | 11525 | 1.50 | 0.89 | 9.44E+06 | 1.07E+07 | 0.231 | 0.104 | 3.84E+06 | 4.84E+06 | 7.28E+06 | 5.61E+06 | 1.10E+07 | 1.27E+06 | 1.10E+07 | 17243 |
| | 8-TXC-V3 | 9110.00 | Vertical | 5000 | 47771 | 17743 | 11400 | 1.56 | 11377 | 1.56 | 1.00 | 1.08E+07 | 1.08E+07 | 0.148 | 0.151 | 4.72E+06 | 4.70E+06 | 6.41E+06 | 6.44E+06 | 1.14E+07 | 2.03E+06 | 1.14E+07 | 23886 |
| | 8-TXC-V4 | 9110.00 | Vertical | 7500 | 58949 | 18038 | 11711 | 1.54 | 11784 | 1.53 | 0.99 | 1.13E+07 | 1.14E+07 | 0.136 | 0.128 | 4.99E+06 | 5.06E+06 | 6.46E+06 | 6.36E+06 | 1.18E+07 | 1.74E+06 | 1.18E+07 | 29474 |
| Lyons | 9-TXC-H | 9155.25 | Horizontal | 5000 | 25157 | | | | | | | | | | | | | | | | | | 12578 |
| | 9-TXC-V1 | 9155.00 | Vertical | 500 | 9615 | 11550 | 6849 | 1.69 | 6918 | 1.67 | 0.99 | 3.35E+06 | 3.40E+06 | 0.229 | 0.220 | 1.36E+06 | 1.39E+06 | 2.57E+06 | 2.52E+06 | 3.88E+06 | 1.10E+06 | 3.88E+06 | 4808 |
| | 9-TXC-V2 | 9155.00 | Vertical | 2500 | 17662 | 11826 | 6864 | 1.72 | 6829 | 1.73 | 1.01 | 3.43E+06 | 3.40E+06 | 0.246 | 0.250 | 1.37E+06 | 1.36E+06 | 2.80E+06 | 2.82E+06 | 4.08E+06 | 1.36E+06 | 4.08E+06 | 8831 |
| | 9-TXC-V3 | 9155.00 | Vertical | 5000 | 27395 | 12182 | 7410 | 1.64 | 7378 | 1.65 | 1.00 | 3.87E+06 | 3.85E+06 | 0.206 | 0.210 | 1.60E+06 | 1.59E+06 | 2.73E+06 | 2.75E+06 | 4.34E+06 | 1.15E+06 | 4.34E+06 | 13698 |
| | 9-TXC-V4 | 9155.00 | Vertical | 7500 | 31720 | 12213 | 7615 | 1.60 | 7735 | 1.58 | 0.98 | 3.99E+06 | 4.06E+06 | 0.182 | 0.165 | 1.69E+06 | 1.74E+06 | 2.60E+06 | 2.51E+06 | 4.34E+06 | 8.59E+05 | 4.34E+06 | 15860 |
| Satanka | 10-TXC-H | 9184.35 | Horizontal | 7500 | 45585 | 15422 | 9973 | 1.55 | 9708 | 1.59 | 1.03 | 8.03E+06 | 7.81E+06 | 0.141 | 0.172 | 3.52E+06 | 3.33E+06 | 4.63E+06 | 4.94E+06 | 8.41E+06 | 1.75E+06 | 8.41E+06 | 22793 |
| | 10-TXC-V1 | 9184.45 | Vertical | 500 | 22152 | 13189 | 9147 | 1.44 | 9159 | 1.44 | 1.00 | 6.08E+06 | 6.09E+06 | 0.037 | 0.034 | 2.93E+06 | 2.94E+06 | 2.75E+06 | 2.73E+06 | 6.10E+06 | 2.17E+05 | 6.10E+06 | 11076 |
| | 10-TXC-V2 | 9184.45 | Vertical | 2500 | 28762 | 14069 | 9313 | 1.51 | 9412 | 1.49 | 0.99 | 6.76E+06 | 6.81E+06 | 0.110 | 0.095 | 3.04E+06 | 3.11E+06 | 3.61E+06 | 3.50E+06 | 6.95E+06 | 7.29E+05 | 6.95E+06 | 14381 |
| | 10-TXC-V3 | 9184.45 | Vertical | 5000 | 37547 | 14712 | 9628 | 1.53 | 9647 | 1.53 | 1.00 | 7.32E+06 | 7.33E+06 | 0.125 | 0.123 | 3.25E+06 | 3.26E+06 | 4.09E+06 | 4.07E+06 | 7.59E+06 | 1.06E+06 | 7.59E+06 | 18774 |
| | 10-TXC-V4 | 9184.45 | Vertical | 7500 | 44012 | 14941 | 9567 | 1.56 | 9611 | 1.55 | 1.00 | 7.41E+06 | 7.44E+06 | 0.153 | 0.147 | 3.22E+06 | 3.24E+06 | 4.46E+06 | 4.41E+06 | 7.84E+06 | 1.35E+06 | 7.84E+06 | 22006 |

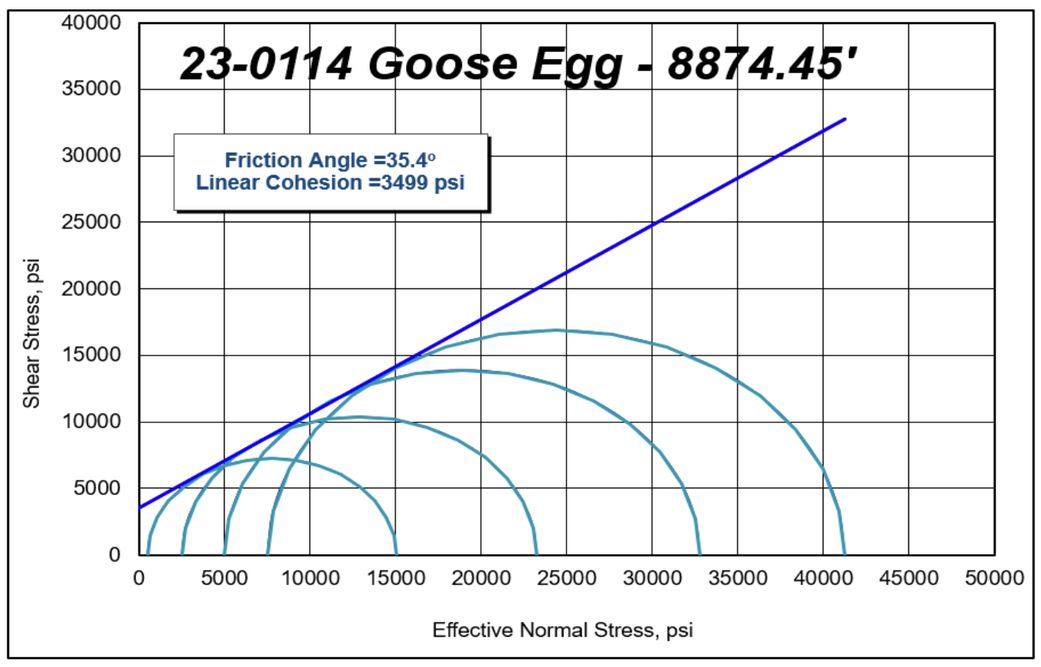
Notes: Blacked out cells indicates no data was collected and/or presented

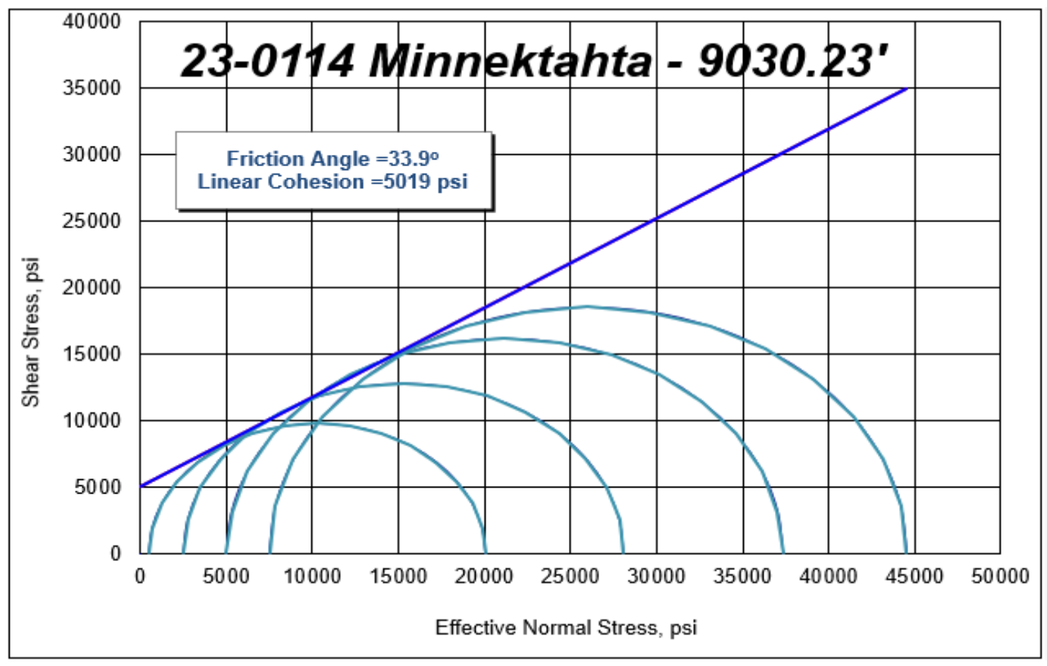
# GEOMECHANICAL REPORT - Mohr Coloumb Plots

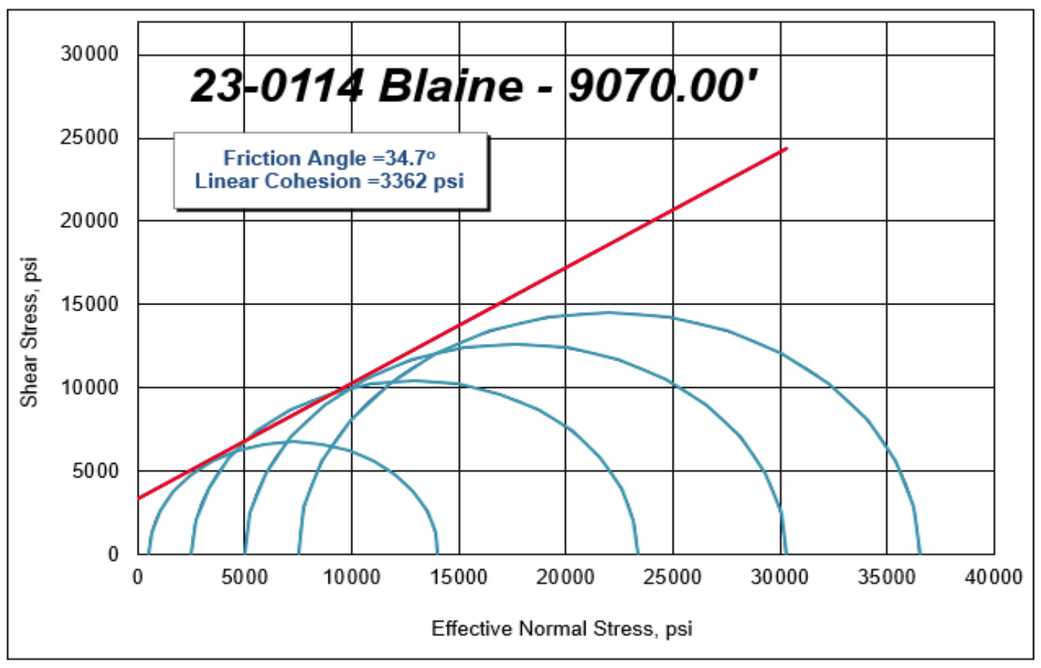
Conventional Core Plug Samples
Triaxial Compressive Strength

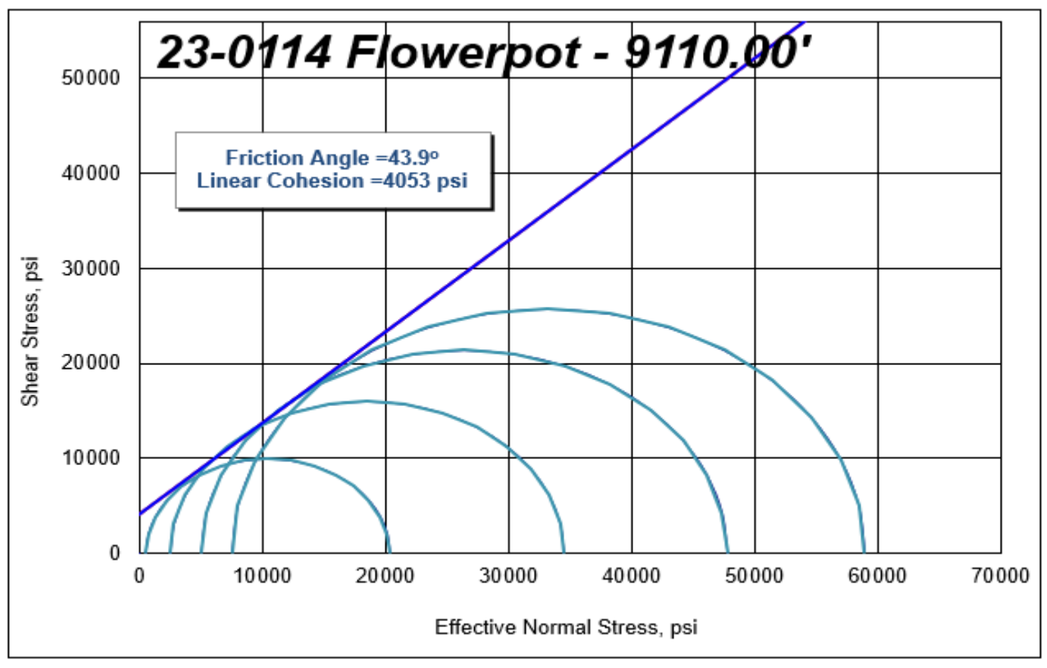
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

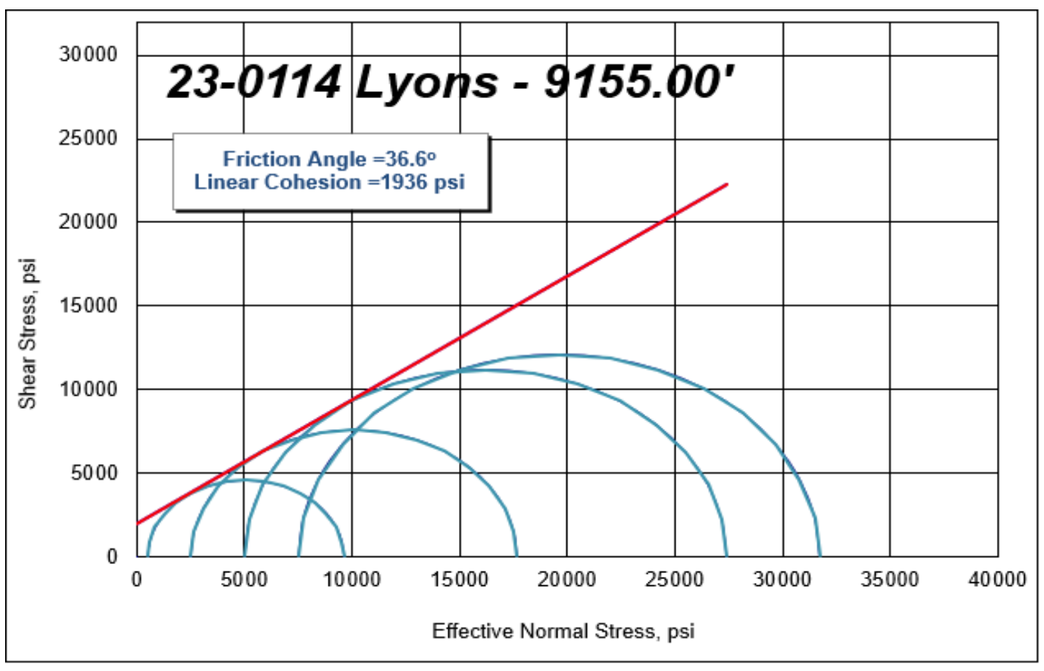
**Report Date:** 11/29/2023
**Project Number:** 23-0114

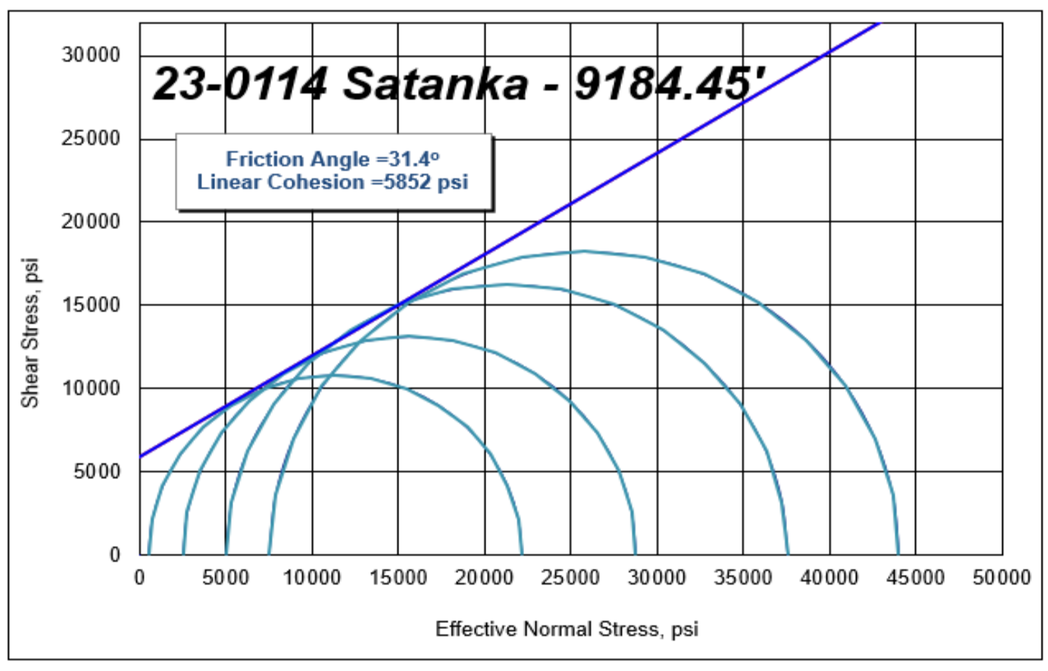


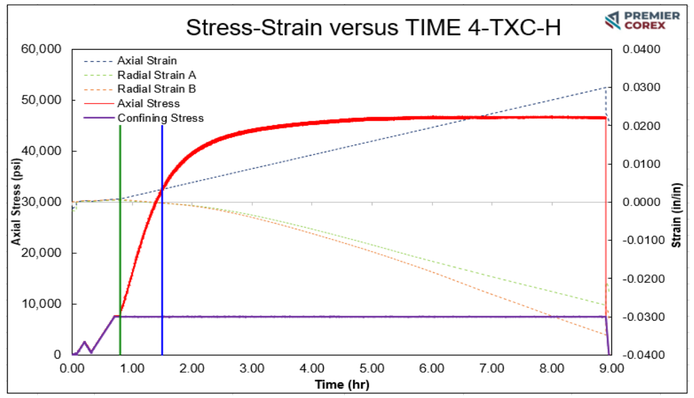

Notes: Blue line indicates the failure envelope used data from all four samples while red line indicates failure envelope used only the three lower confining pressure samples

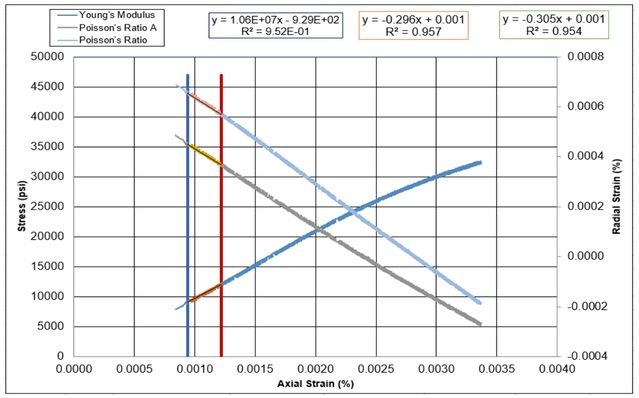
# GEOMECHANICAL REPORT - Stress & Strain Plots

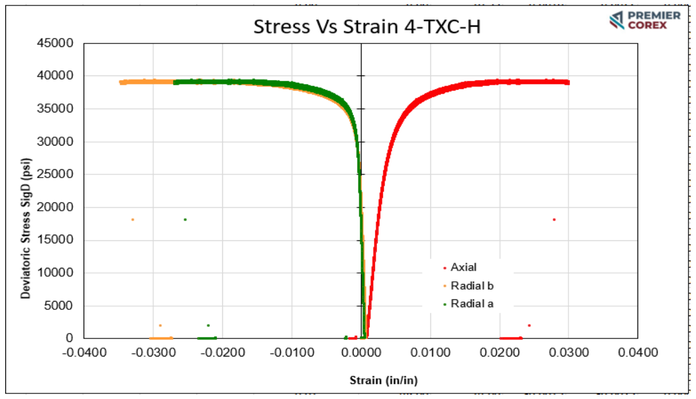
Conventional Core Plug Samples
Group 4 - Goose Egg Formation

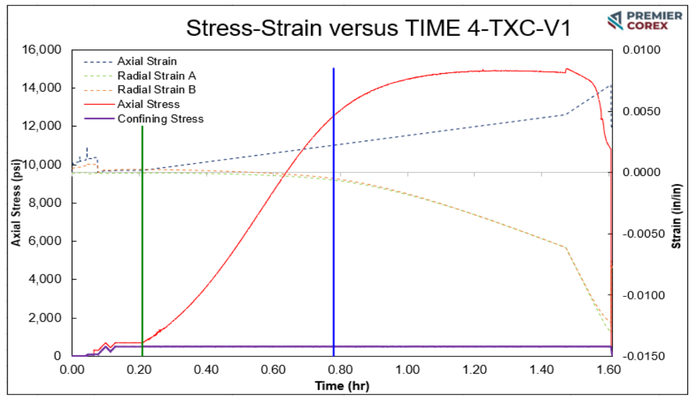
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

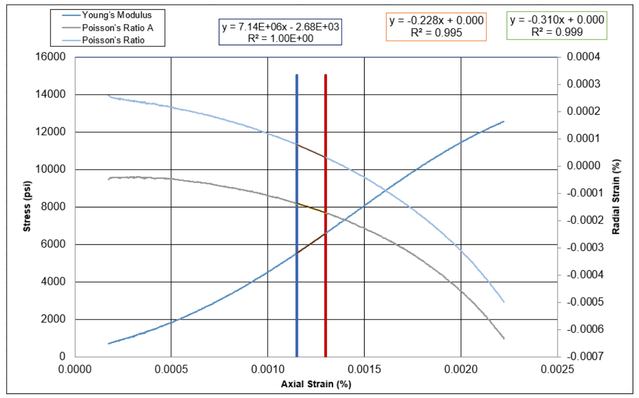
**Report Date:** 11/29/2023
**Project Number:** 23-0114

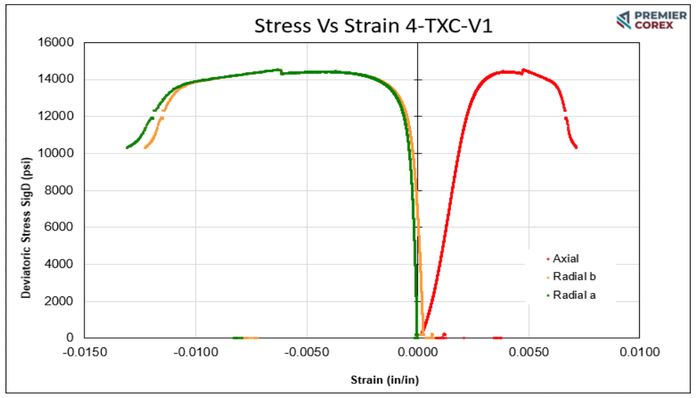


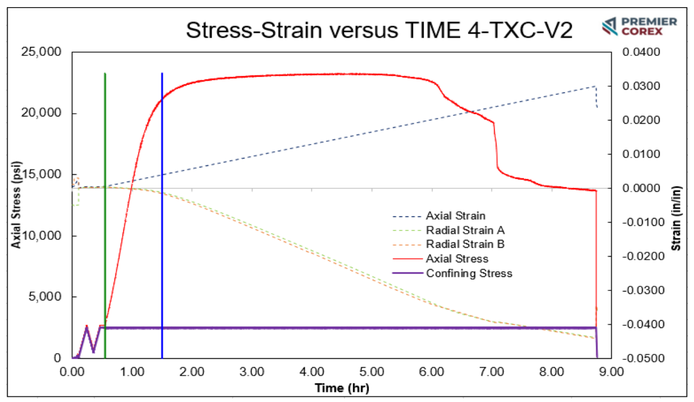



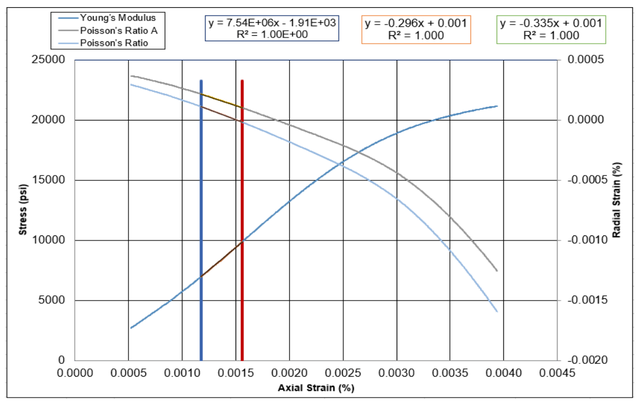



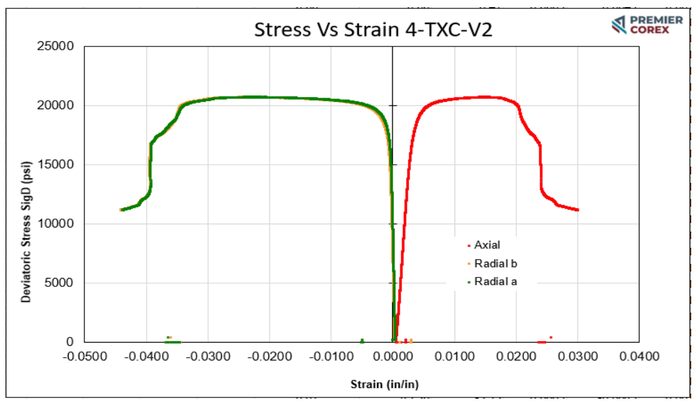



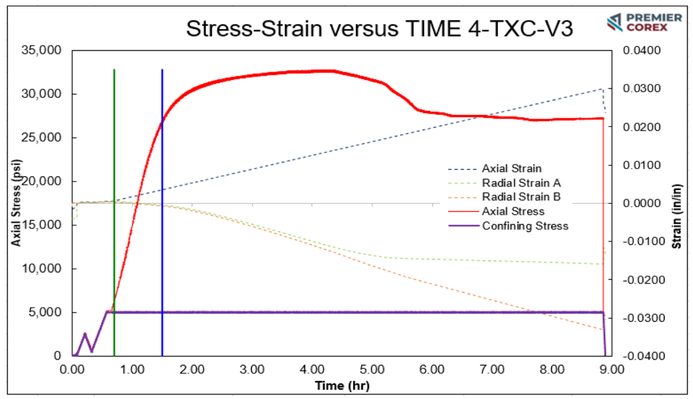



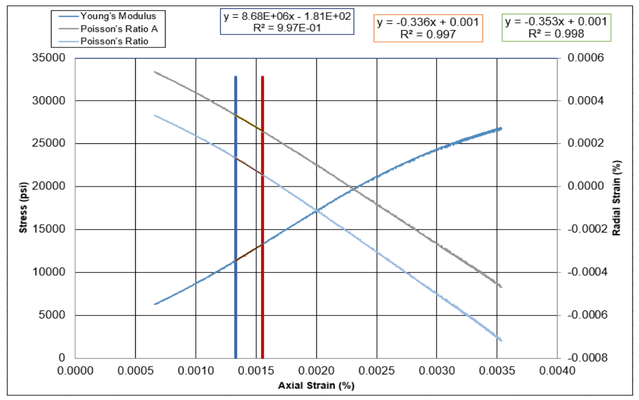
# GEOMECHANICAL REPORT - Stress & Strain Plots

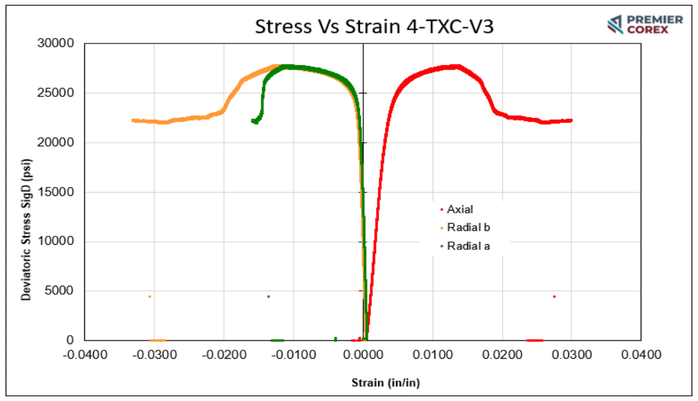
Conventional Core Plug Samples
Group 4 - Goose Egg Formation

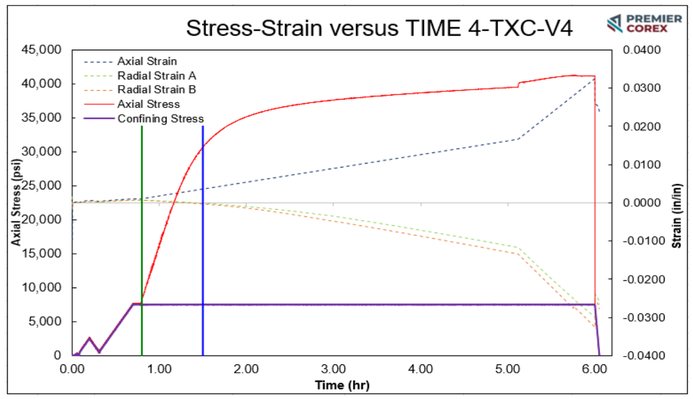
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

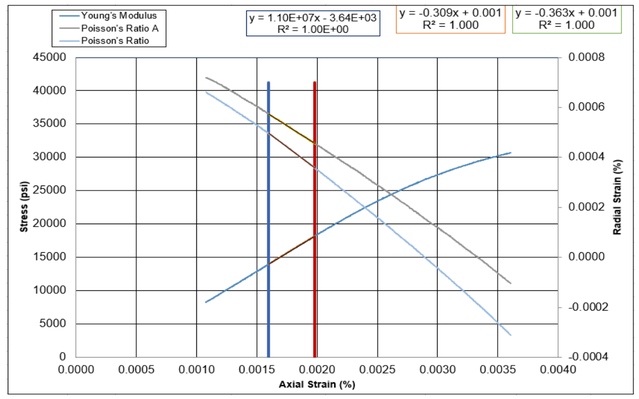
**Report Date:** 11/29/2023
**Project Number:** 23-0114

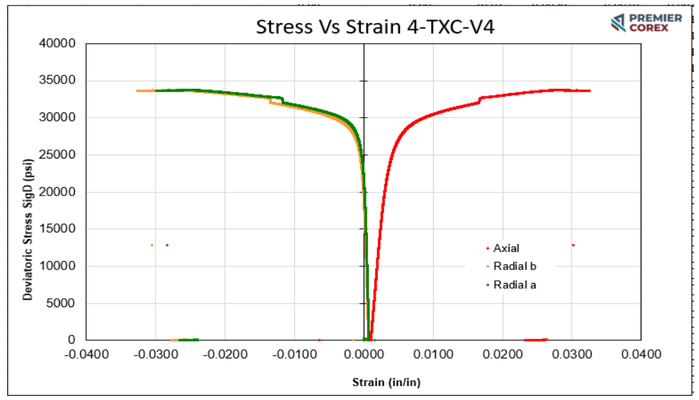


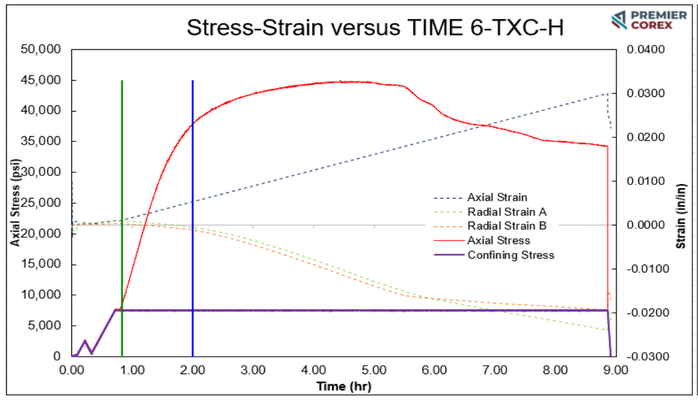



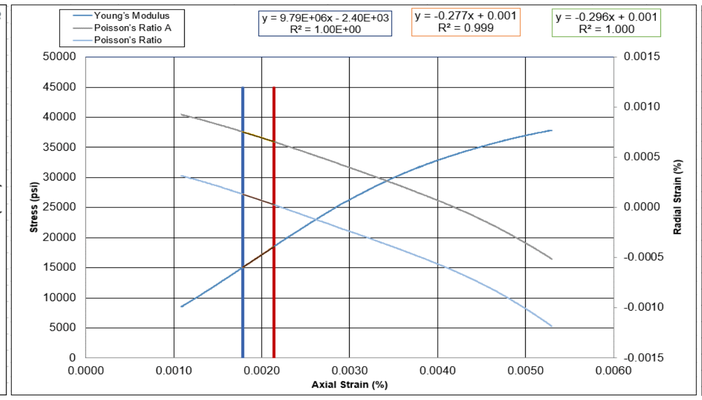
# GEOMECHANICAL REPORT - Stress & Strain Plots

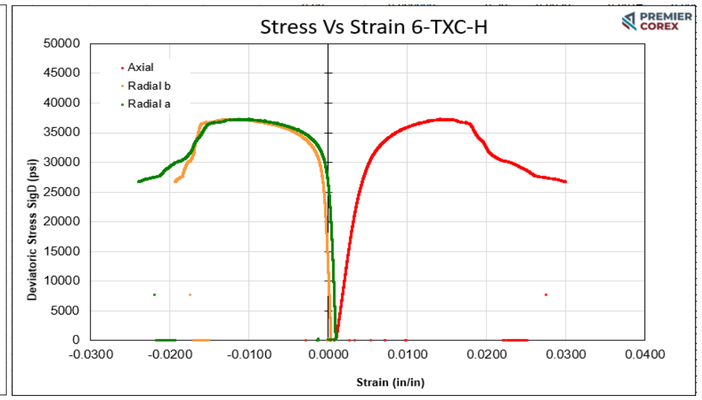
Conventional Core Plug Samples
Group 6 - Minnektahta Formation

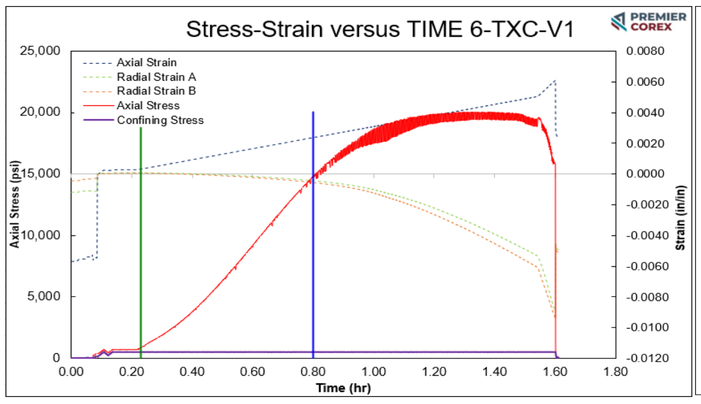
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

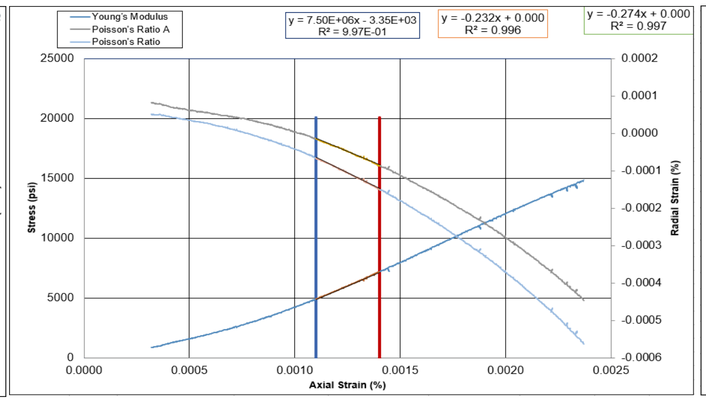
**Report Date:** 11/29/2023
**Project Number:** 23-0114

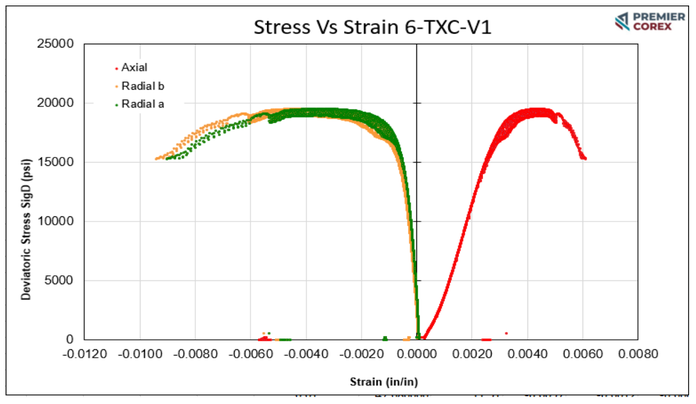


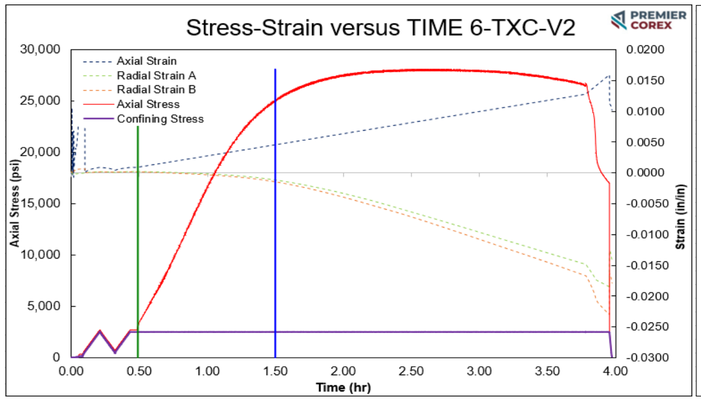



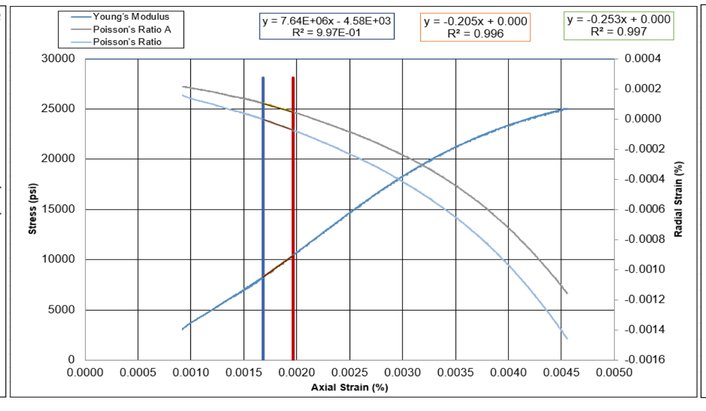



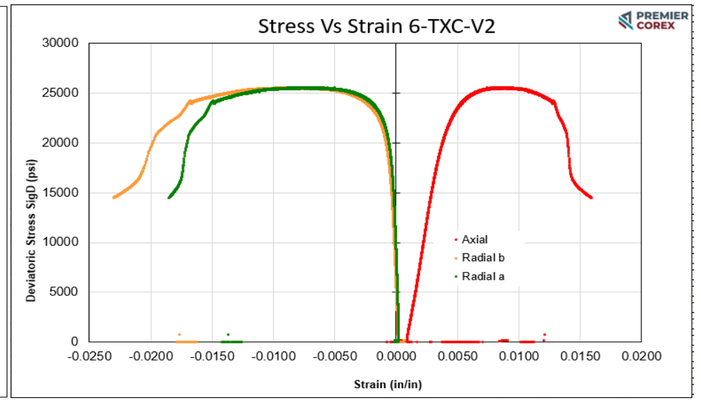



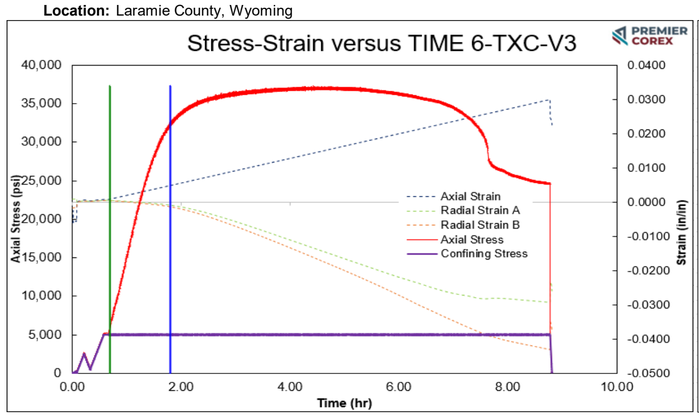



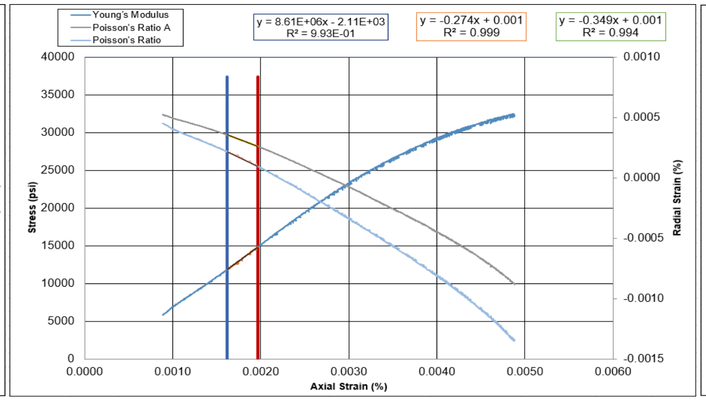
# GEOMECHANICAL REPORT - Stress & Strain Plots

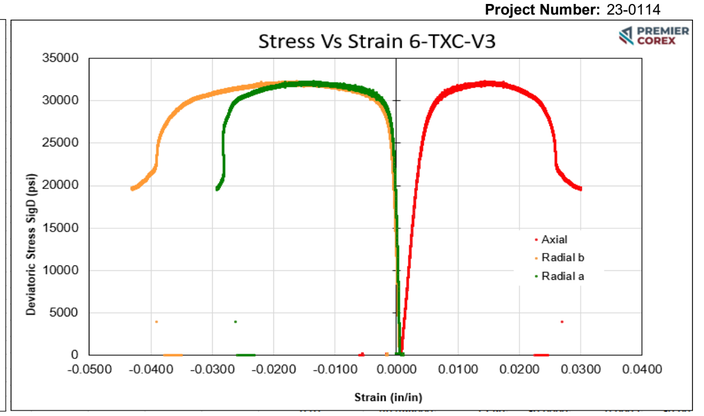
Conventional Core Plug Samples
Group 6 - Minnektahta Formation

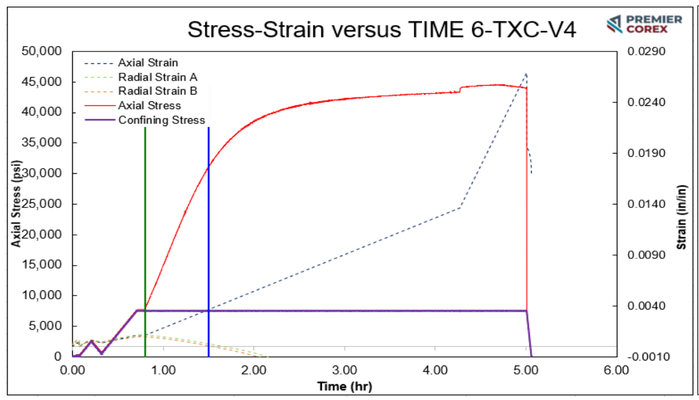
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

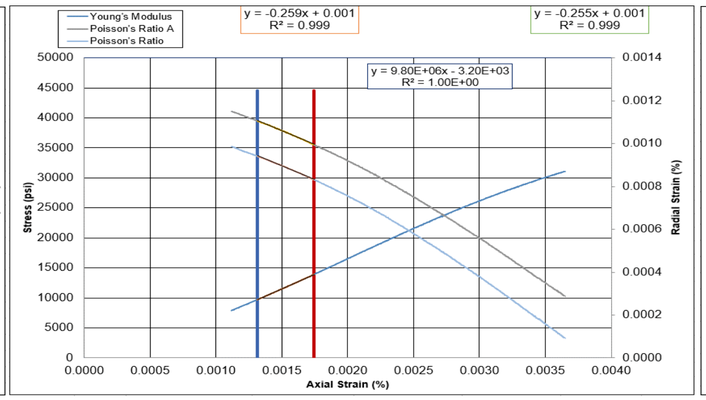
**Report Date:** 11/29/2023
**Project Number:** 23-0114

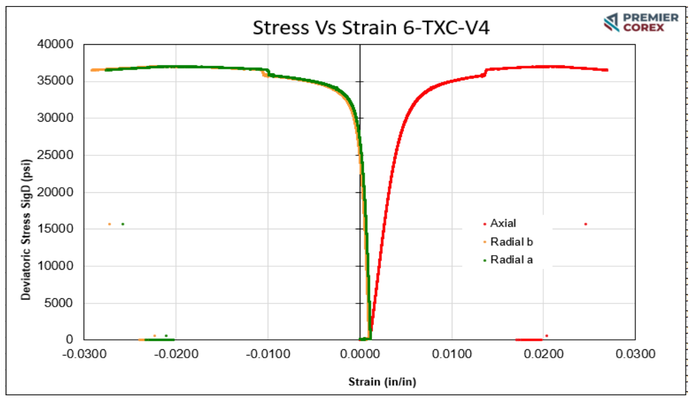


# GEOMECHANICAL REPORT - Stress & Strain Plots

Conventional Core Plug Samples
Group 6 - Minnektahta Formation

**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

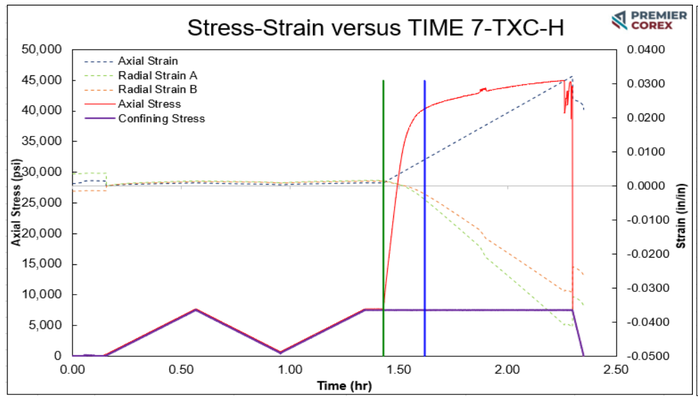
**Report Date:** 11/29/2023
**Project Number:** 23-0114

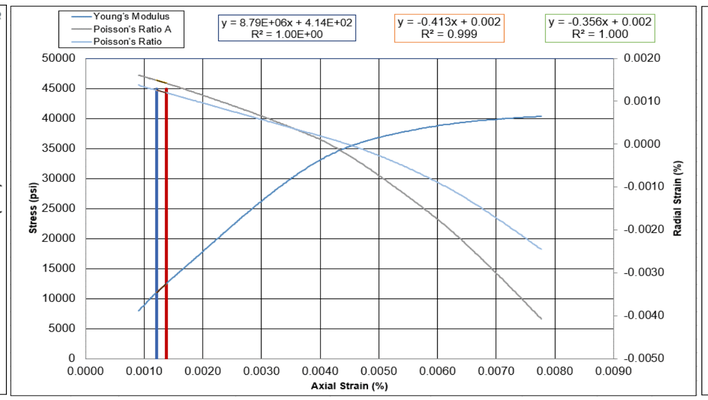
# GEOMECHANICAL REPORT - Stress & Strain Plots

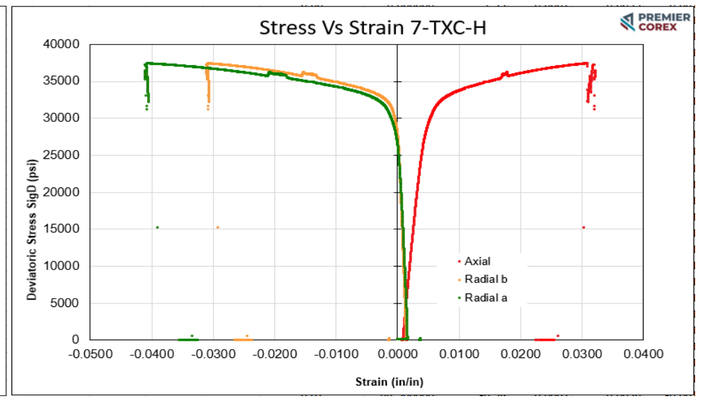
Conventional Core Plug Samples
Group 7 - Blaine Formation

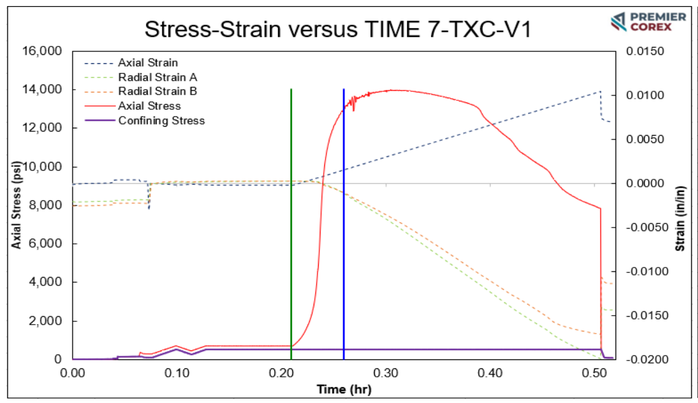
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

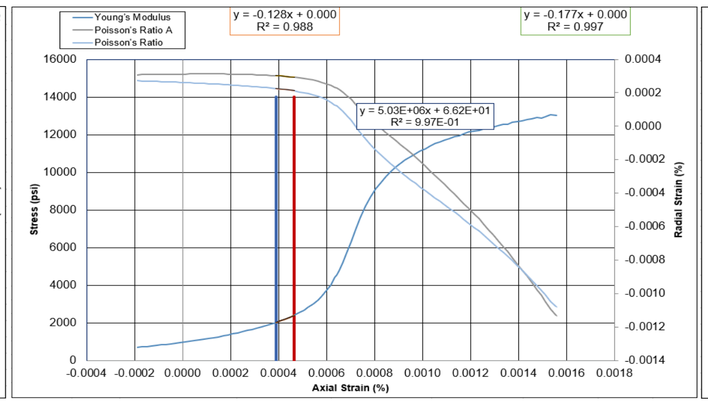
**Report Date:** 11/29/2023
**Project Number:** 23-0114

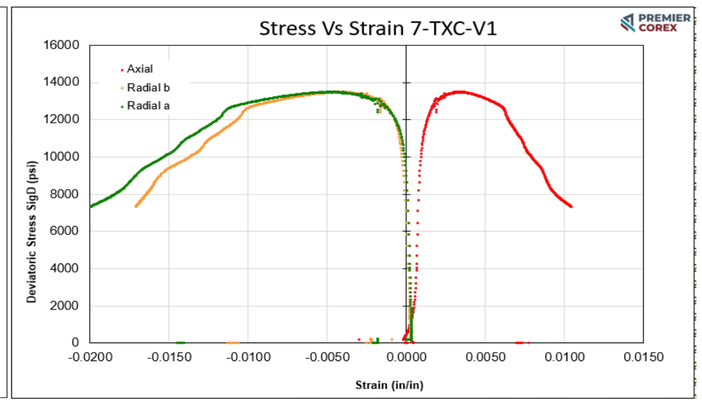


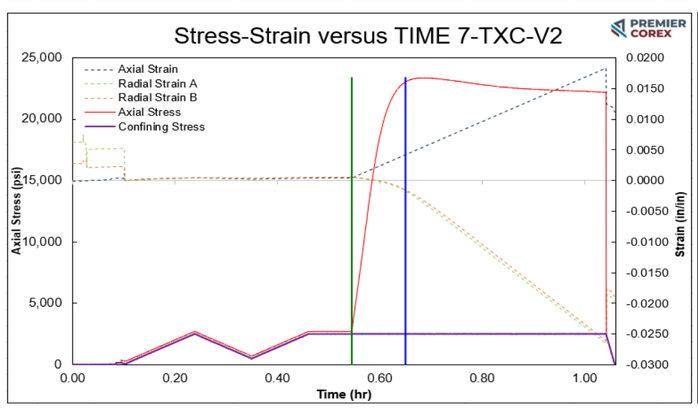



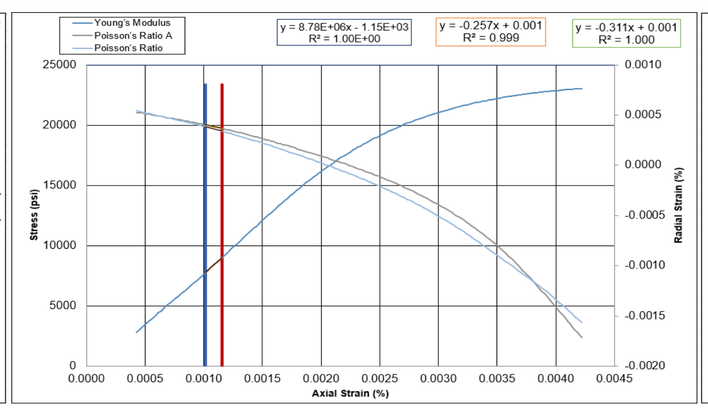



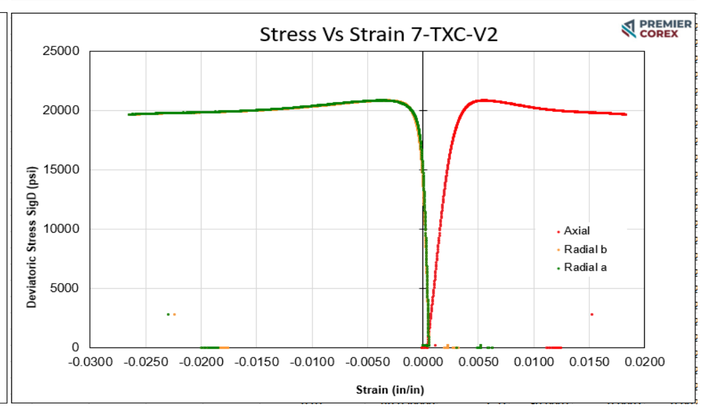



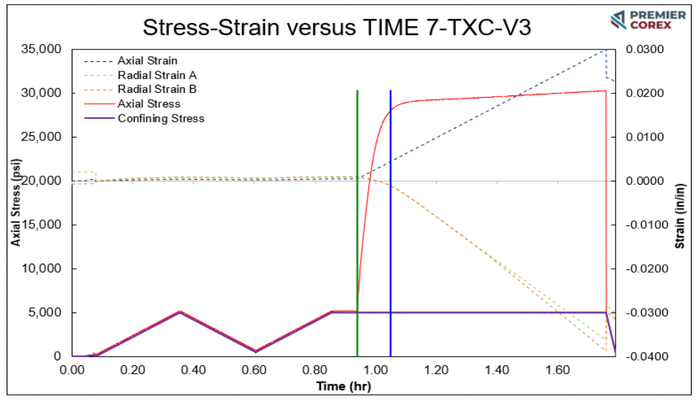



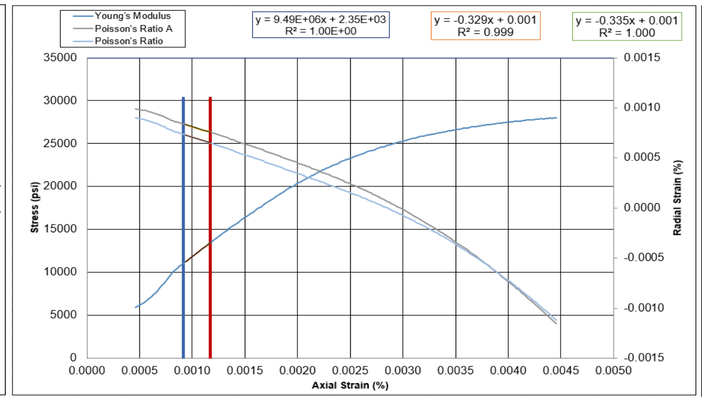
# GEOMECHANICAL REPORT - Stress & Strain Plots

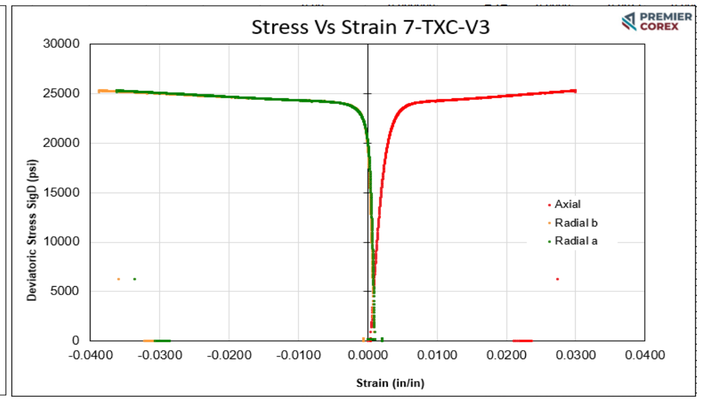
Conventional Core Plug Samples
Group 7 - Blaine Formation

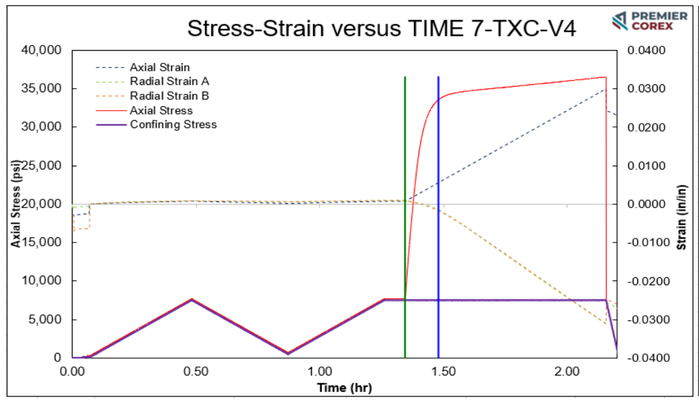
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

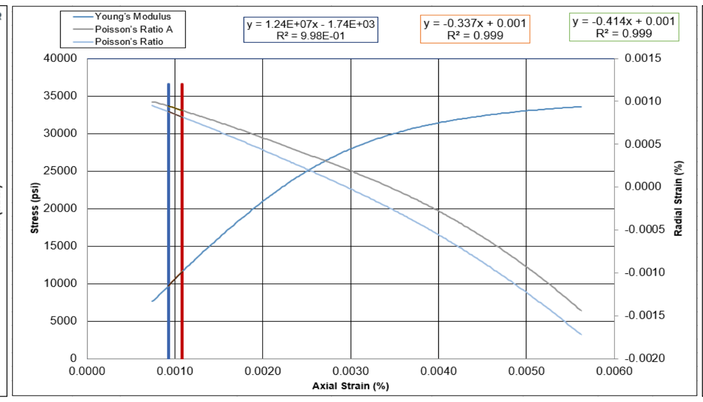
**Report Date:** 11/29/2023
**Project Number:** 23-0114

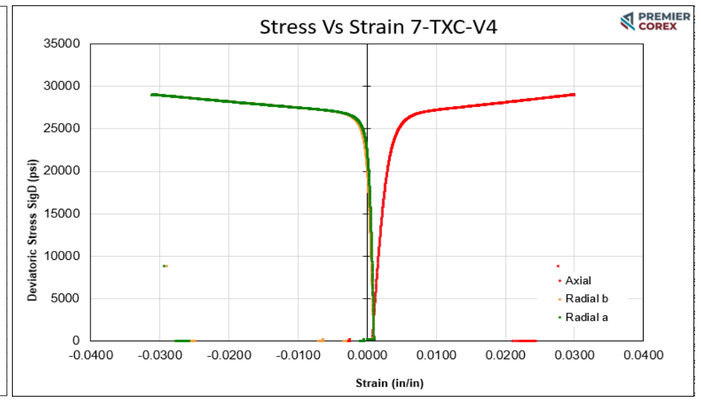


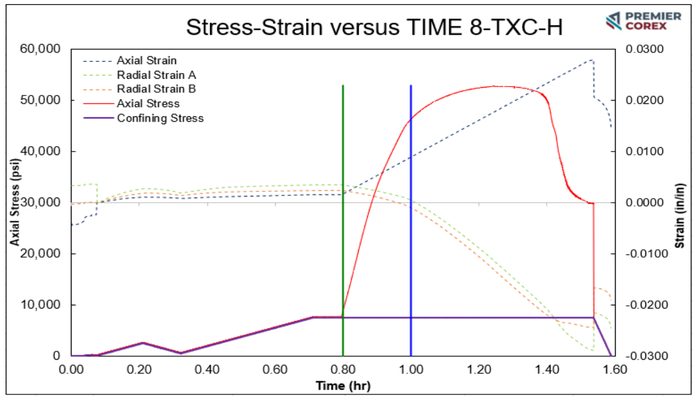



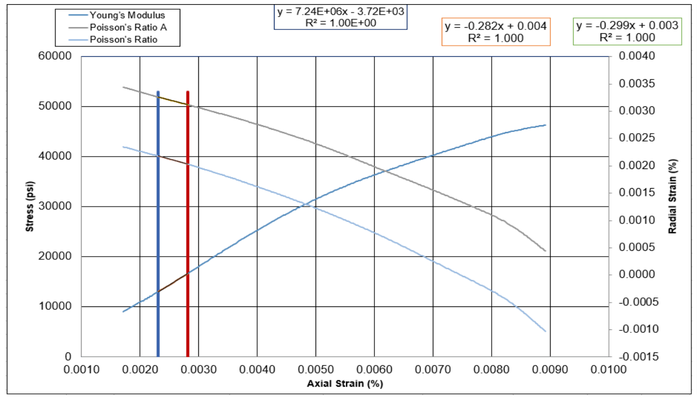
# GEOMECHANICAL REPORT - Stress & Strain Plots

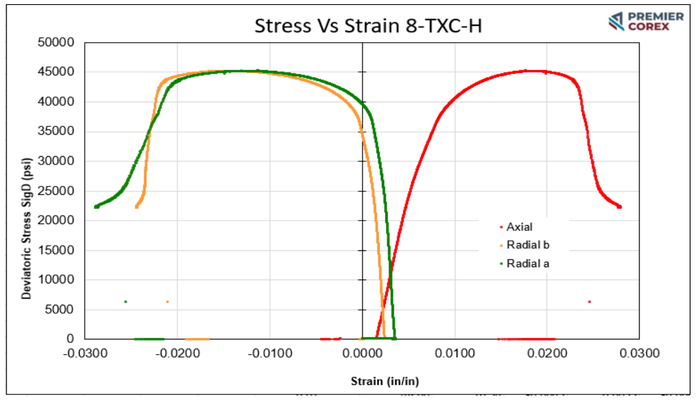
Conventional Core Plug Samples
Group 8 - Flowerpot Formation

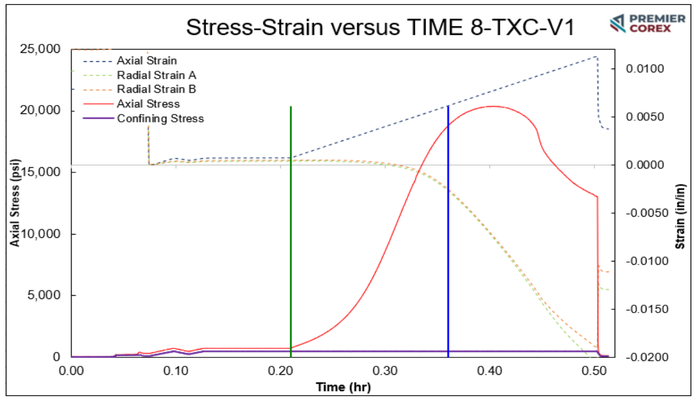
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

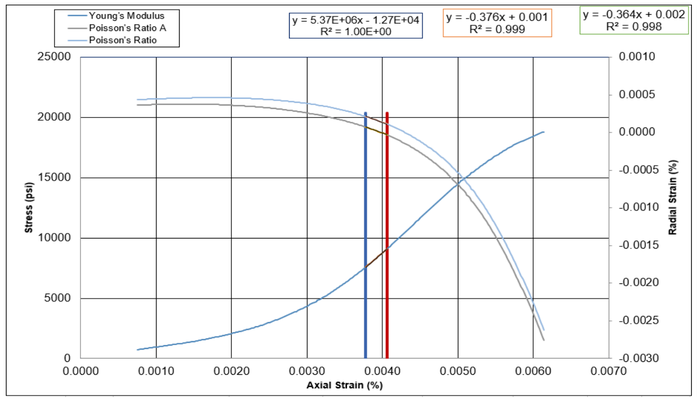
**Report Date:** 11/29/2023
**Project Number:** 23-0114

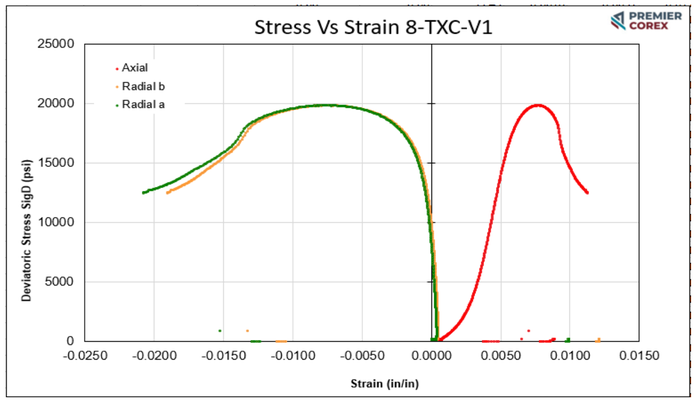


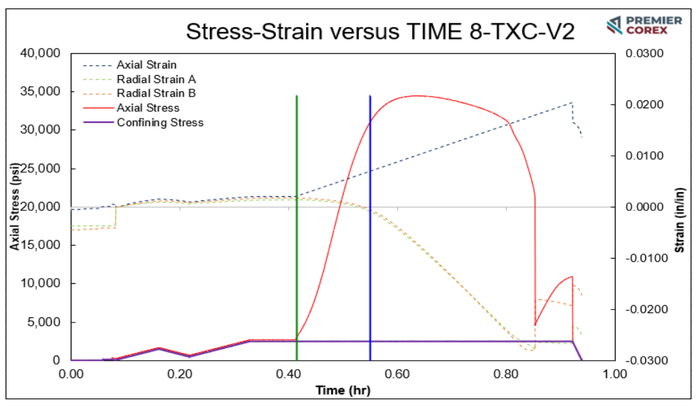



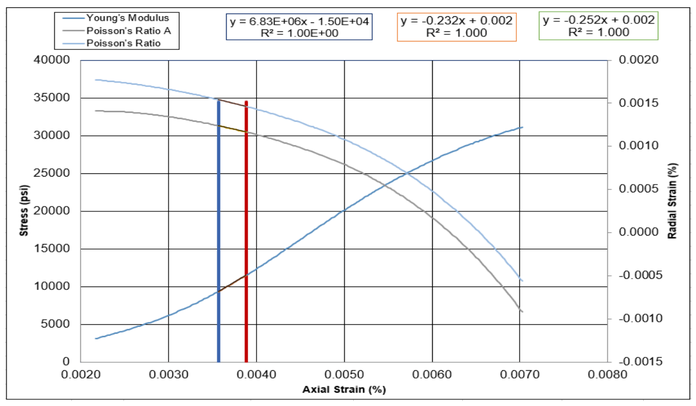



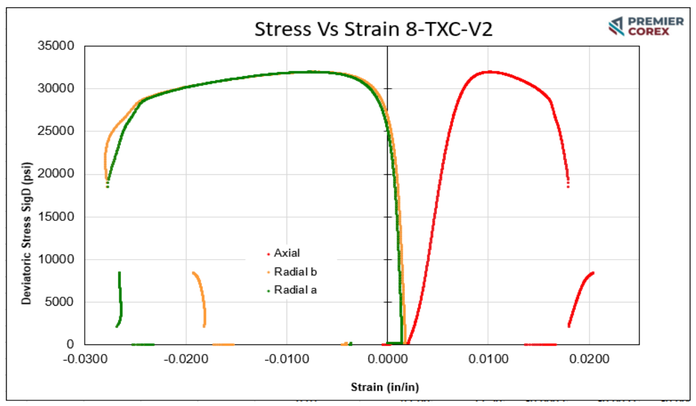



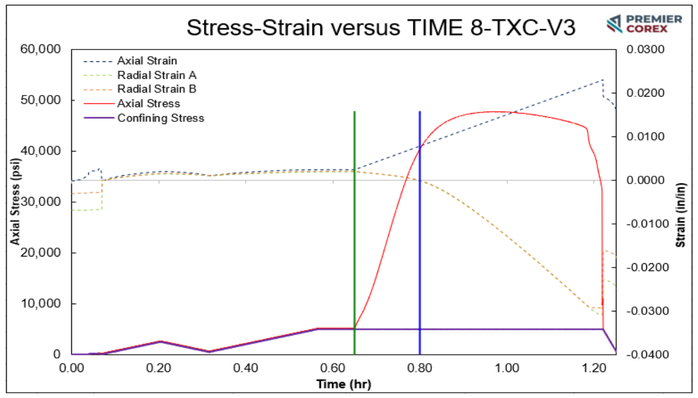



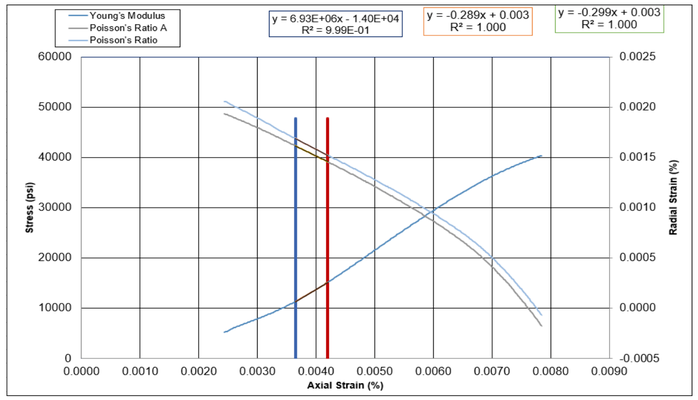
# GEOMECHANICAL REPORT - Stress & Strain Plots

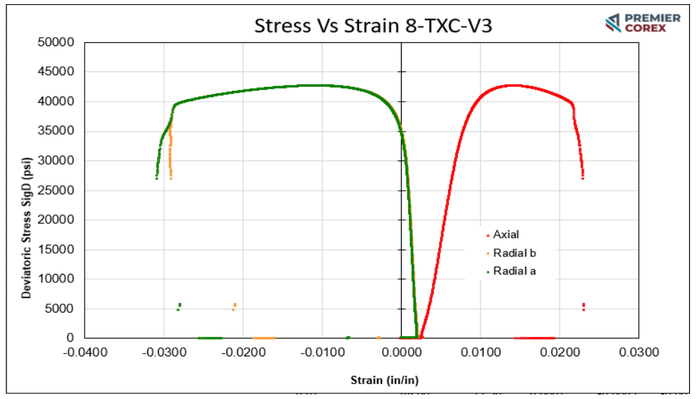
Conventional Core Plug Samples
Group 8 - Flowerpot Formation

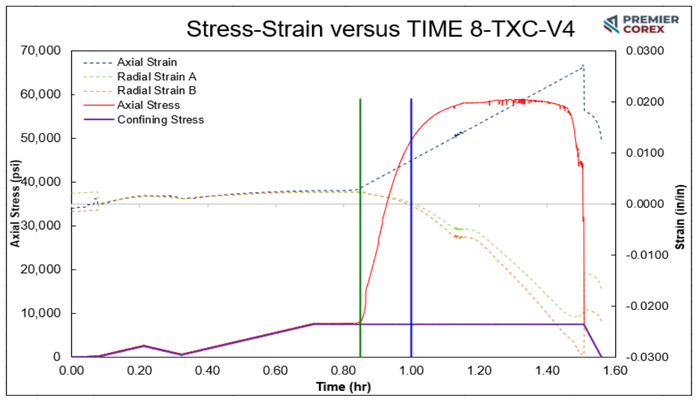
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

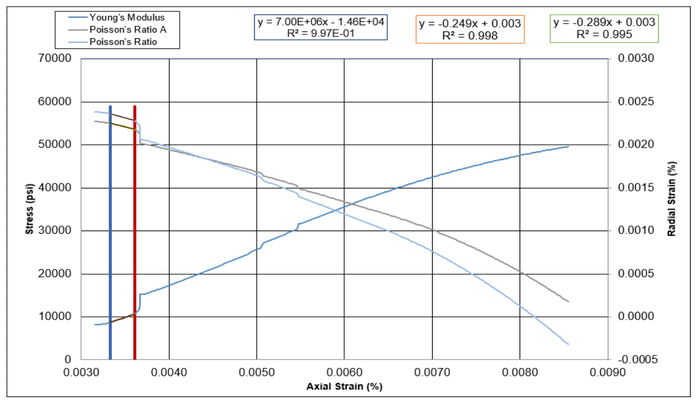
**Report Date:** 11/29/2023
**Project Number:** 23-0114

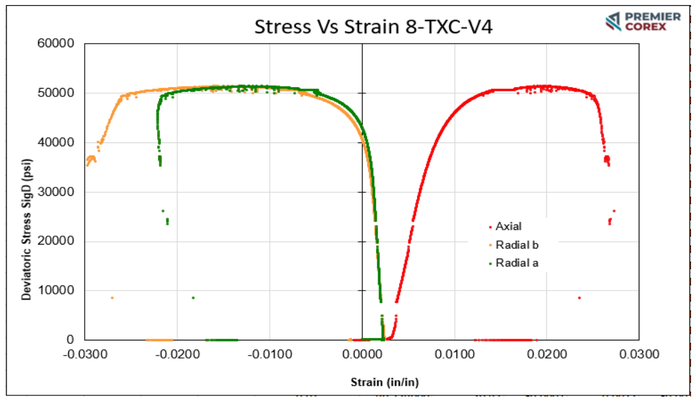


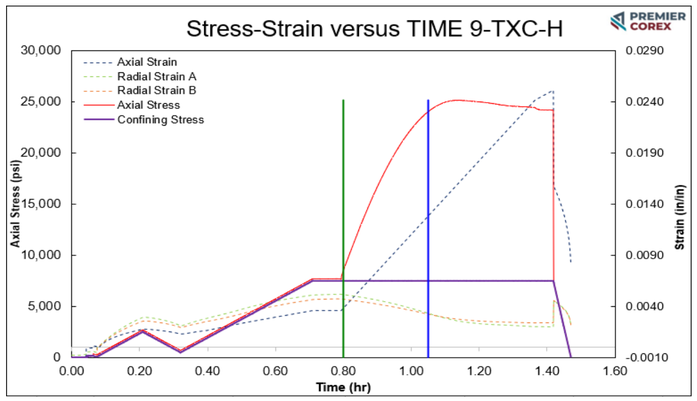



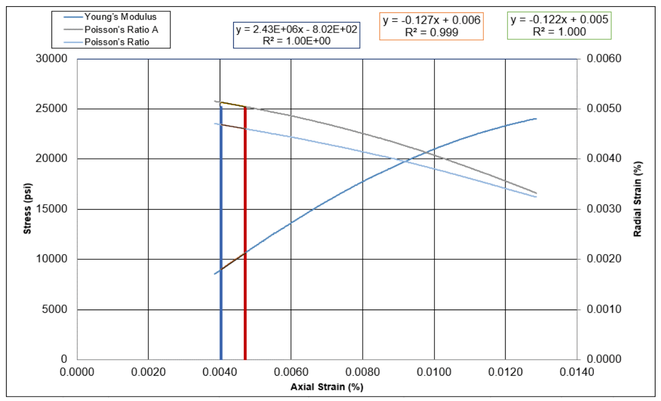
# GEOMECHANICAL REPORT - Stress & Strain Plots

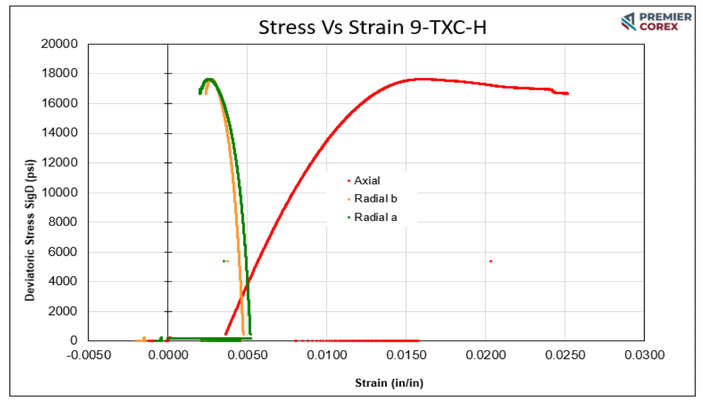
Conventional Core Plug Samples
Group 9 - Lyons Formation

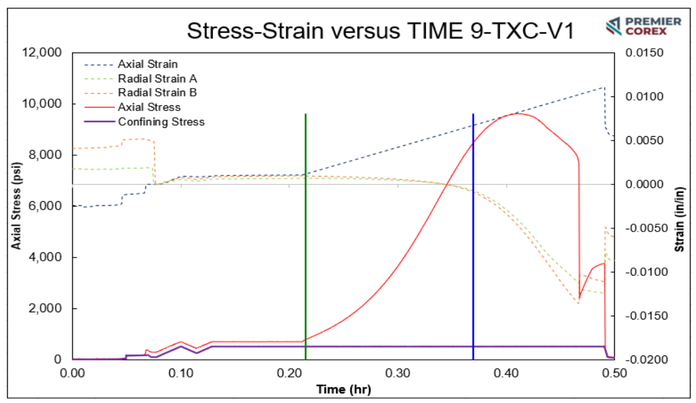
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

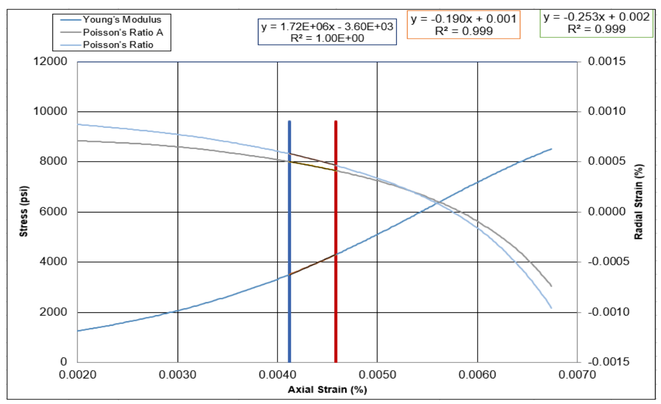
**Report Date:** 11/29/2023
**Project Number:** 23-0114

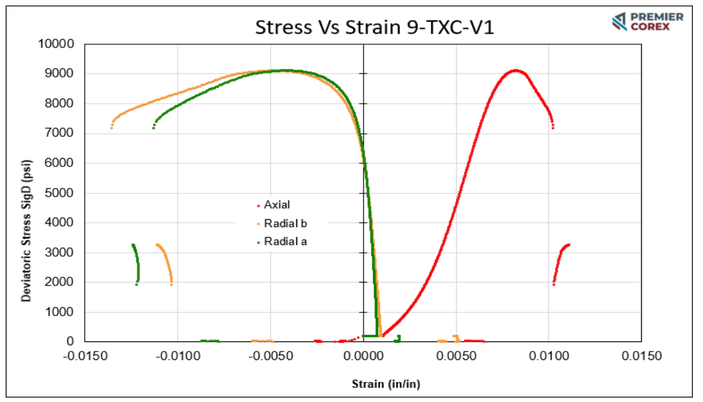


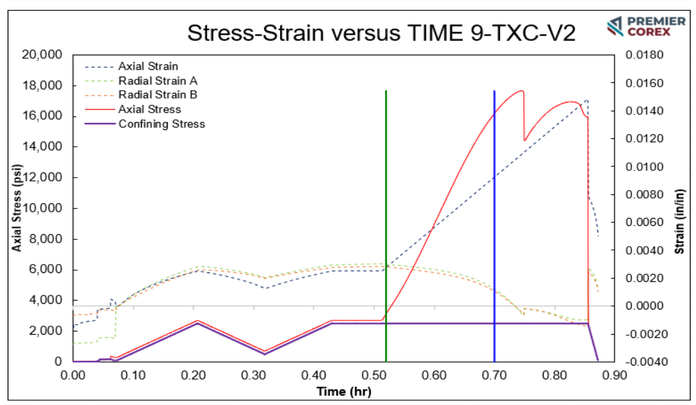



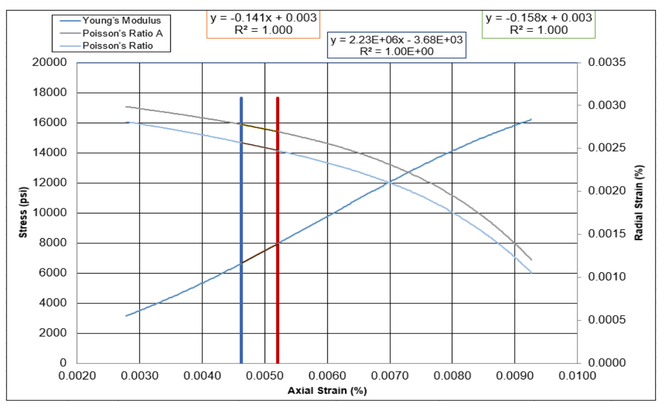



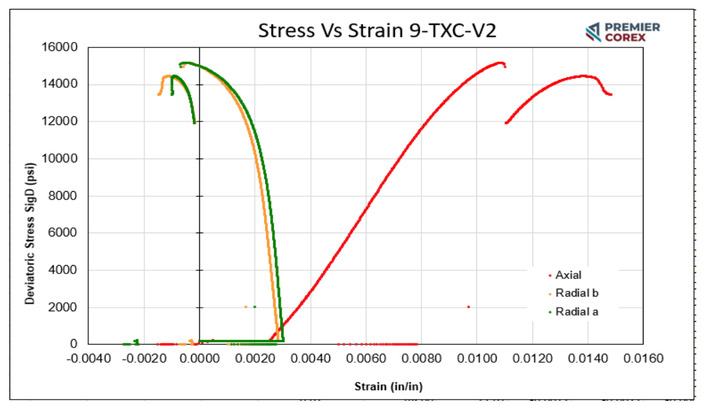



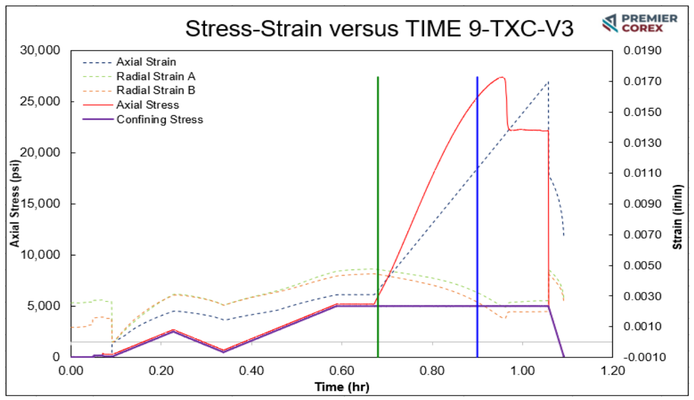



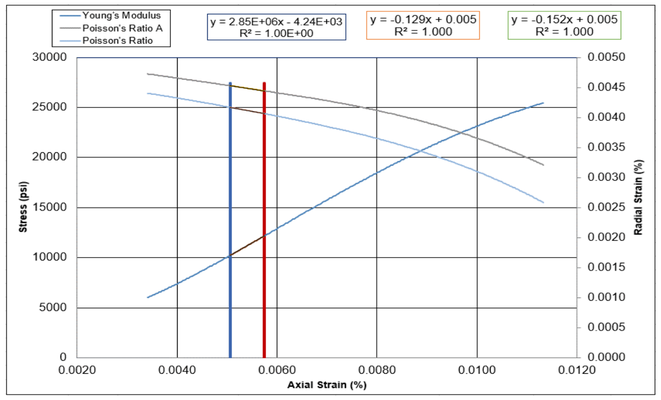
# GEOMECHANICAL REPORT - Stress & Strain Plots

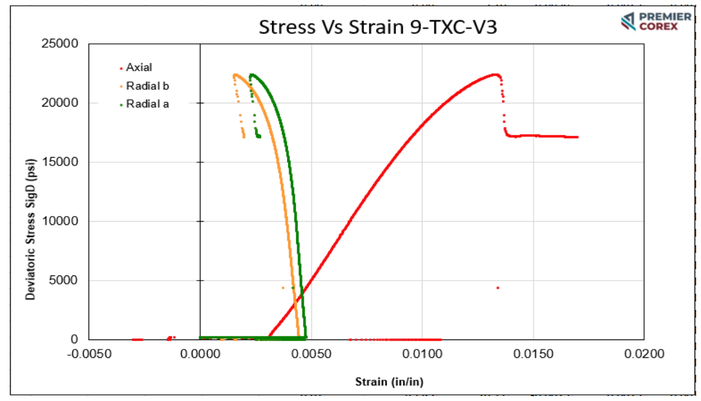
Conventional Core Plug Samples
Group 9 - Lyons Formation

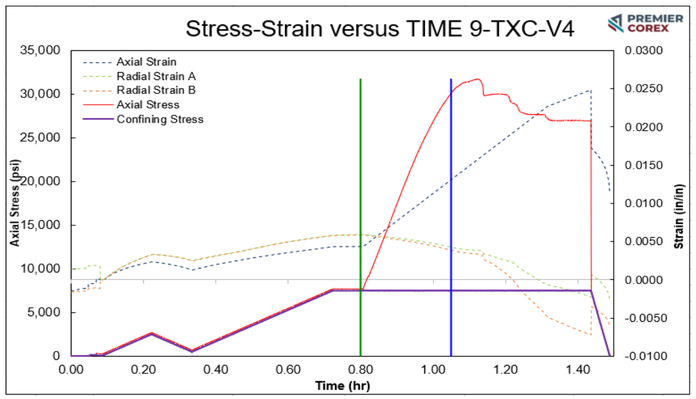
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

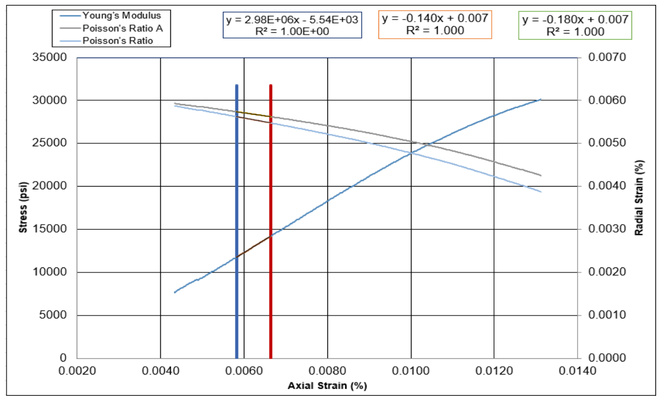
**Report Date:** 11/29/2023
**Project Number:** 23-0114

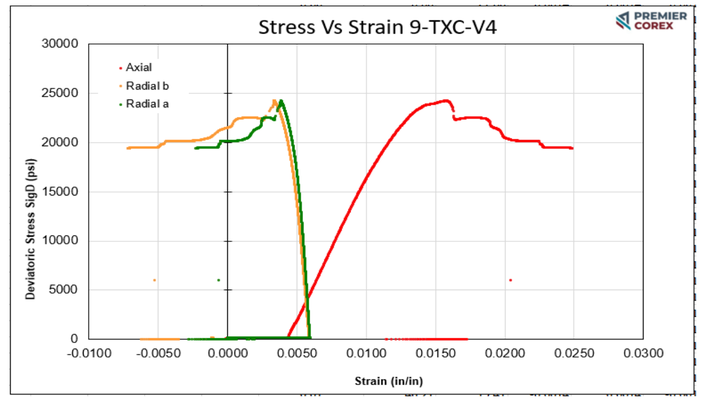


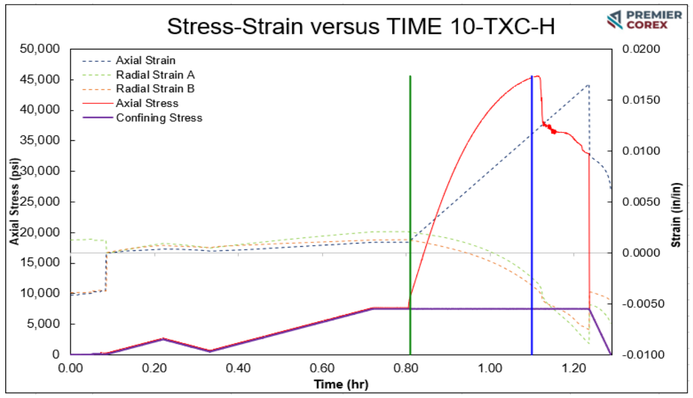



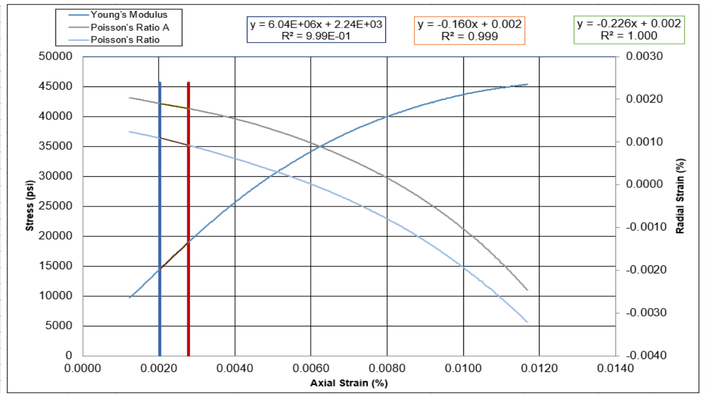
# GEOMECHANICAL REPORT - Stress & Strain Plots

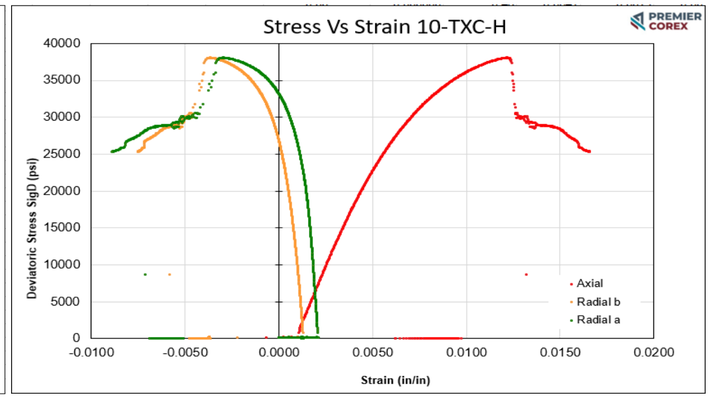
Conventional Core Plug Samples
Group 10 - Satanka Formation

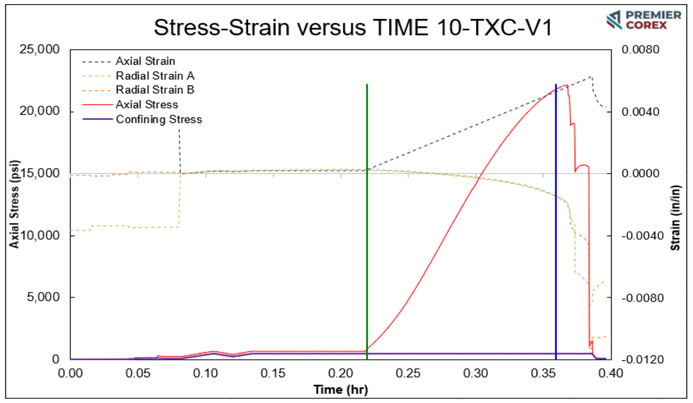
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

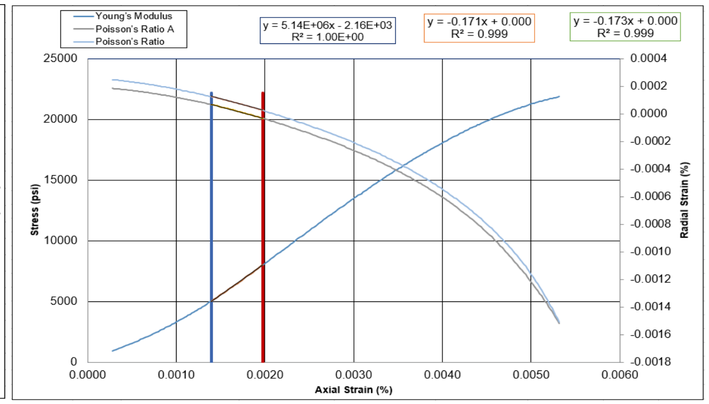
**Report Date:** 11/29/2023
**Project Number:** 23-0114

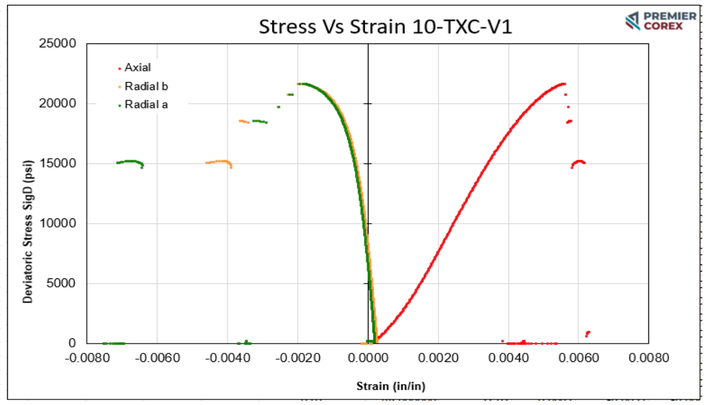


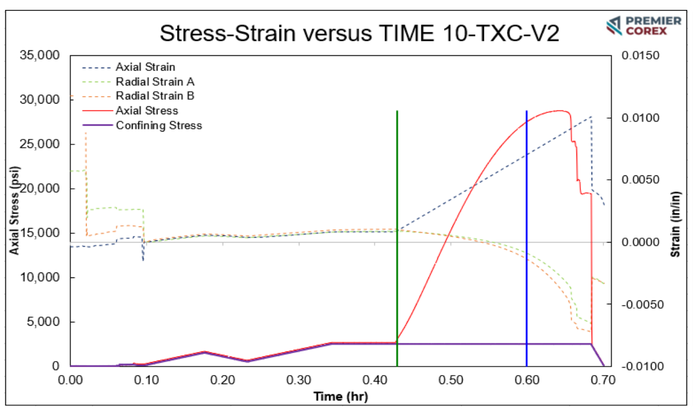



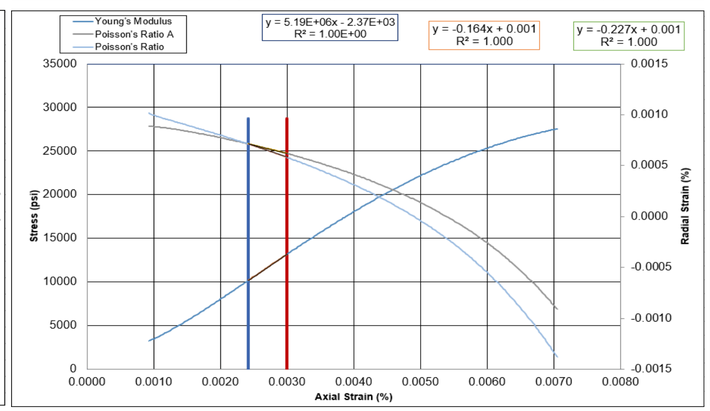



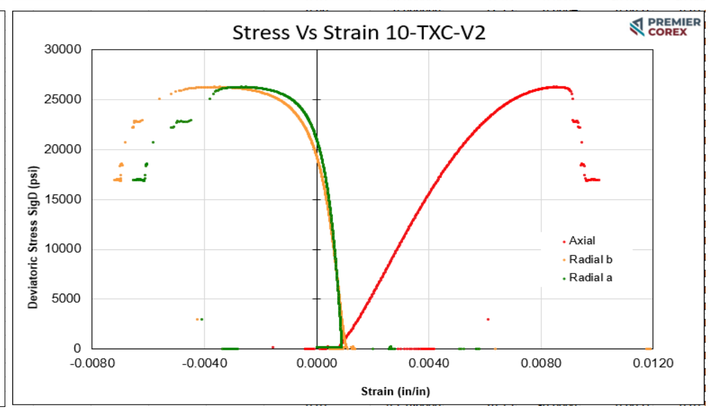



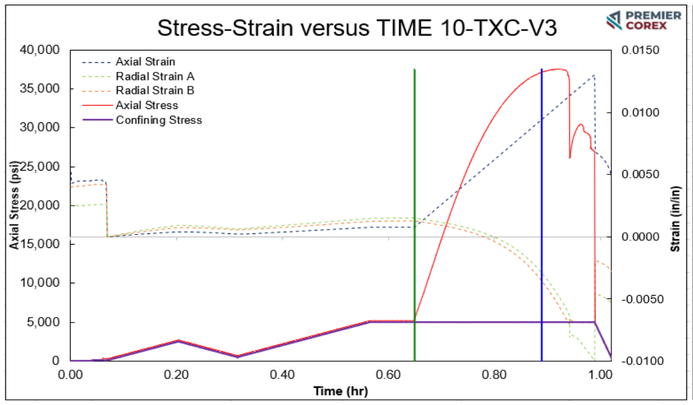



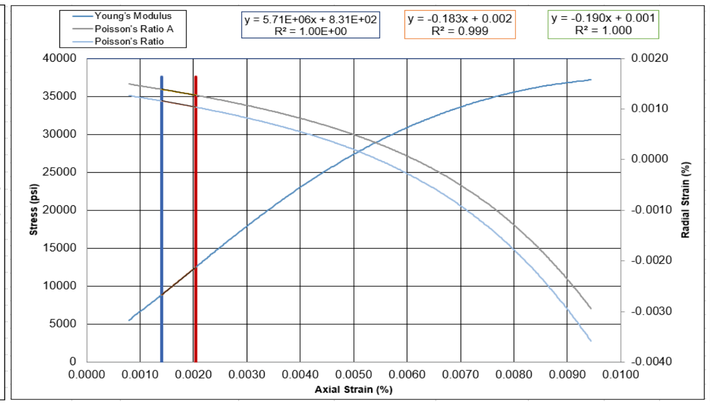
# GEOMECHANICAL REPORT - Stress & Strain Plots

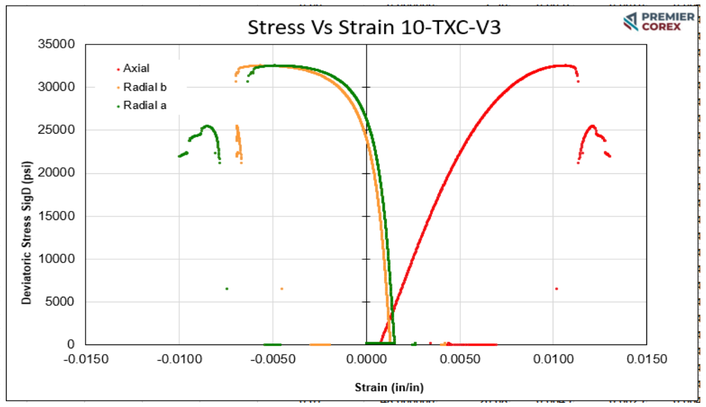
Conventional Core Plug Samples
Group 10 - Satanka Formation

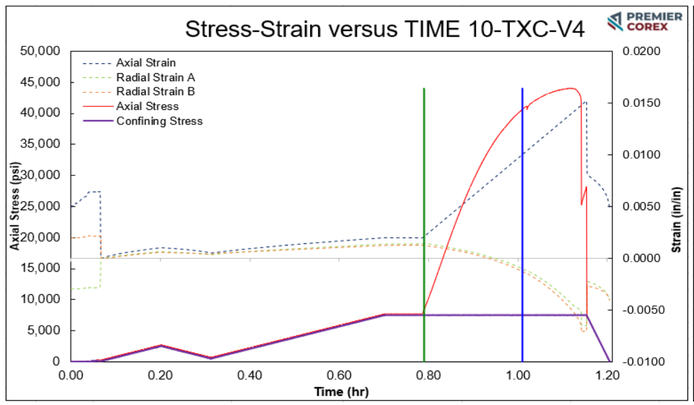
**Client:** Devon Energy LLC
**Well:** Tallgrass - Juniper M1
**Location:** Laramie County, Wyoming

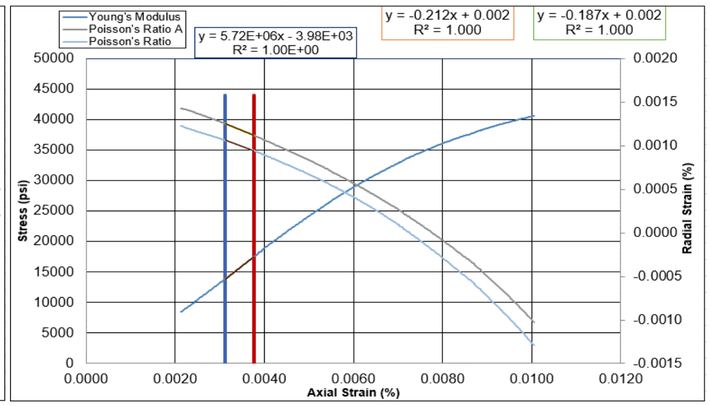
**Report Date:** 11/29/2023
**Project Number:** 23-0114

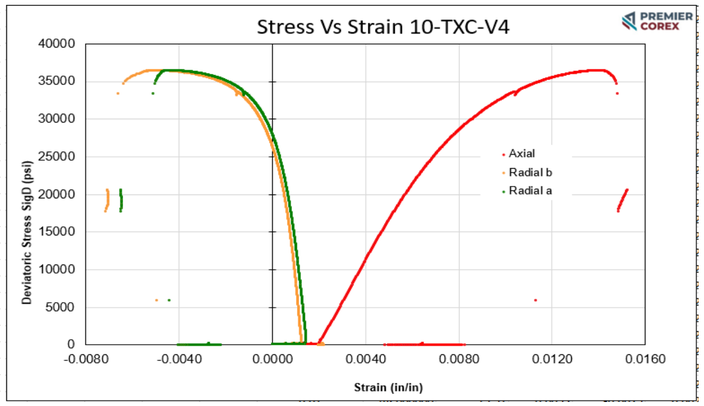


**Response to Specific Comments, SC-4**

**Juniper M-1 MDT Results**

| | Juniper M-1 MDT Pretest Results | | | | | | | | | Final Saturn Probe Sampling Program | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fm** | **SLB File No.** | **SLB Test No.** | **Actual Depth ft** | **MDT Run** | **Actual Pretest Order** | **Last BU Press. psi** | **Fm Press BU psi** | **Press Grad psi/ft** | **Mob mD/cP** | **MPSR (450 cc)** | **MRSC (1gal)** |
| Lyons | 16 | 32 | 9130.0 | MDT R2 | Pretest #18 | 3078.65 | 3078.65 | 0.337 | 0.02 | | |
| | 15 | 30 | 9139.9 | MDT R2 | Pretest #17 | 3140.23 | 3140.23 | 0.344 | 183.48 | | |
| | 14 | 28 | 9144.0 | MDT R2 | Pretest #16 | 3143.75 | 3143.75 | 0.344 | 0.28 | | |
| | 13 | 26 | 9148.1 | MDT R2 | Pretest #15 | 3144.18 | 3144.18 | 0.344 | 304.23 | | |
| | 5 | 10 | 9165.9 | MDT R2 | Pretest #7 | 3152.07 | 3152.07 | 0.344 | 464.26 | 1 brine and 1 mud | 1 brine |
| | 12 | 24 | 9177.0 | MDT R2 | Pretest #14 | 3158.35 | 3158.35 | 0.344 | 114.55 | | |
| | 6 | 12 | 9188.1 | MDT R2 | Pretest #8 | 3164.70 | 3164.70 | 0.344 | 24.82 | | |

**Juniper M-1 MDT Program**

| Original MDT Program | | | | | Actual MDT Downlog | | | | | | | | | Actual MDT Uplog | | | | | | | | Final Saturn Probe Sampling Program | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MD R1 (ft) | PreTest Order | Fm | MPSR (450 cc) | MRSC (1gal) | SLB File No. | SLB Test No. | Actual Depth ft | MDT Run | Actual Pretest Order | Last BU Press. psi | Fm Press. psi | Press Grad psi/ft | Mob mD/cP | SLB File No. | SLB Test No. | Actual Depth ft | MDT Run | Actual Pretest Order | Last BU Press. psi | Fm Press BU psi | Press Grad psi/ft | Mob mD/cP | MPSR (450 cc) | MRSC (1gal) |
| 9130 | Pretest #4 | | | | 2 | 3 | 9130.2 | MDT R2 | Pretest #4 | 449.46 | Dry | Dry | Dry | 16 | 32 | 9130.0 | MDT R2 | Pretest #18 | 3078.65 | 3078.65 | 0.337 | 0.02 | | |
| 9140 | Pretest #5 | | | | 3 | 6 | 9140.0 | MDT R2 | Pretest #5 | 224.12 | Dry | Dry | Dry | 15 | 30 | 9139.9 | MDT R2 | Pretest #17 | 3140.23 | 3140.23 | 0.344 | 183.48 | | |
| 9144 | Pretest #6 | | | | 4 | 8 | 9144.1 | MDT R2 | Pretest #6 | 3141.47 | 3141.47 | 0.344 | 66.47 | 14 | 28 | 9144.0 | MDT R2 | Pretest #16 | 3143.75 | 3143.75 | 0.344 | 0.28 | | |
| | | Lyons | 1 brine and 1 mud | 1 brine | | | | | | | | | | 13 | 26 | 9148.1 | MDT R2 | Pretest #15 | 3144.18 | 3144.18 | 0.344 | 304.23 | | |
| 9166 | Pretest #7 | | | | 5 | 10 | 9165.9 | MDT R2 | Pretest #7 | 3152.07 | 3152.07 | 0.344 | 464.26 | | | | | | | | | | 1 brine and 1 mud | 1 brine |
| | | | | | | | | | | | | | | 12 | 24 | 9177.0 | MDT R2 | Pretest #14 | 3158.35 | 3158.35 | 0.344 | 114.55 | | |
| 9188 | Pretest #8 | | | | 6 | 12 | 9188.1 | MDT R2 | Pretest #8 | 3164.70 | 3164.70 | 0.344 | 24.82 | | | | | | | | | | | |

**Response to Specific Comments, SC-5**

**SLB SRS Specs**

Schlumberger

# Single-Phase Reservoir Sampler

## Advanced sampling system for all downhole applications

### APPLICATIONS

- All subsurface sampling operations requiring unaltered, uncontaminated single-phase samples
- Flow assurance studies
- Aquifer pH studies

### BENEFITS

- Reliable operation
- Fast sample transfer

### FEATURES

- Single-phase pressure compensation
- Positive displacement operation
- Mercury-free operation
- No recombination necessary
- No sample flashing during sampling
- Sample retrieval without phase change

The single-phase reservoir sampler (SRS) is a specialized system for all subsurface sampling applications. The SRS design maintains the sample in a single-phase condition above reservoir pressure as the tool is retrieved from the hole.

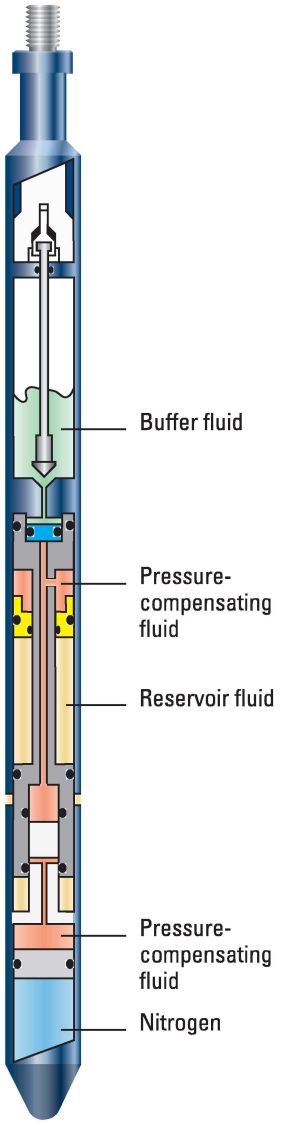
This technology provides truly representative samples and is essential for measurements requiring samples in unaltered condition, such as pressurized pH measurements in formation water or asphaltene deposition analysis in oil.

The SRS allows controlled, uncontaminated reservoir sampling without sample flashing. The unaltered sample is retrieved at the surface in single-phase state, requiring no recombination before transfer. Without the necessity of sample recombination, the sample transfer takes minutes instead of hours.

This mercury-free, pressure-compensating bottomhole sampling tool can be run in strings of up to eight tools on slickline, wireline, electric line, coiled tubing, or sucker pump rods. Each tool has its own programmable timer, allowing complete flexibility in deciding when, and at what depth, each individual tool in the string takes a sample.

**Technical Specifications**

| | SRS | SRS with Inconel® 725 |
|---|---|---|
| Length, ft [m] | 13.5 [4.1] | 13.5 [4.1] |
| Weight, lbm [kg] | 77 [35] | 77 [35] |
| Max. OD, in [mm] | 1.75 [44] | 1.75 [44] |
| Sample capacity, $in^3$ [$cm^3$] | 37 [600] | 37 [600] |
| Test pressure, psi [mPa] | 22,500 [155] | 22,500 [155] |
| Working pressure, psi [mPa] | 15,000 [103] | 15,000 [103] |
| Working temperature, degF [degC] | 392 [200] | 410 [210] |
| Max. time delay, d | 7 | 7 |
| Service | Sour | Extreme sour |
| Design code | API 6A | API 6A, NACE MR0175 |
| Certifying authority | Bureau Veritas | Bureau Veritas |




*Single-phase reservoir sampler.*

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**Response to Specific Comments, SC-8**

**EverCRETE_SLB_Specs**

Schlumberger

# EverCRETE $CO_2$-resistant cement system

## Extend cement barrier lifetime in reservoirs containing $CO_2$

Aligned with United Nations Sustainable Development Goals: 12—Responsible consumption and production, 13—Climate action.

**$CO_2$ Reduction:**
Serves as barrier for $CO_2$ storage wells or high $CO_2$-producing formations. Lowers $CO_2$ footprint during well construction due to significantly reduced usage of Portland cement.

**Temperature:**
up to 284 degF [140 degC]

### Applications

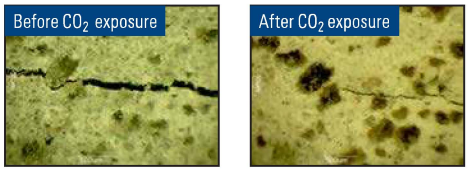
- Carbon capture and storage wells
- Wells in fields that use $CO_2$ injection for enhanced oil recovery (EOR)
- Primary cementing in $CO_2$ environments
- Long-term decommissioning objectives for plug and abandonment (P&A) in $CO_2$ environments

### How it improves wells

Because of its intrinsic low permeability, EverCRETE* $CO_2$-resistant cement system resists cement matrix attack from wet supercritical $CO_2$ and water saturated with $CO_2$ conditions. Accelerated reaction kinetics lead to a stabilized matrix within days of exposure to the $CO_2$ environment, leading to stabilized mechanical properties.

### How it works

EverCRETE system blends can be prepared locally using the standard bulk plant. The density can be tailored to well requirements, providing operational flexibility. Unlike other offerings, EverCRETE system is compatible with portland cement. The EverCRETE system can be used as a cement across potential $CO_2$-producing formations or as the primary barrier in the wellbore for any in situ fluids, with a portland cement-based slurry used as a filler slurry for coverage of remaining casing. It can be prepared and pumped using standard equipment. Additionally, the cement can be engineered with self-healing properties that are reactive to $CO_2$ exposure.




### What it replaces

Portland cement systems are used conventionally for zonal isolation in wells. However, portland cement is thermodynamically unstable in $CO_2$-rich environments and can degrade rapidly upon exposure to $CO_2$ in the presence of water. As $CO_2$-laden water diffuses into the cement matrix, the dissociated acid ($H_2CO_3$) reacts with the free calcium hydroxide and the calcium silicate hydrate (C-S-H) gel. The reaction products are soluble and migrate out of the cement matrix. Eventually, the compressive strength of the set cement decreases and the permeability and porosity increase, leading to loss of zonal isolation.

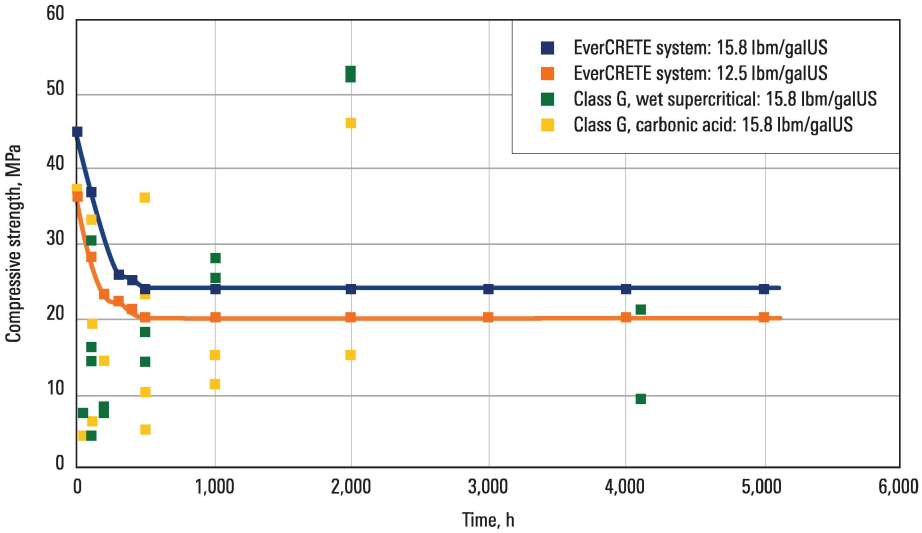
### Why it's ideal in any $CO_2$ environment

Well integrity has been identified as the biggest risk contributing to leakage of $CO_2$ from underground carbon capture and storage sites. EverCRETE system enables efficient underground storage and keeps greenhouse gases out of the atmosphere.

For wells in fields that use $CO_2$ injection for EOR or may use it in the future, EverCRETE system reduces the risk of cement sheath degradation and leakage. It can be used to cement new $CO_2$ injection wells or to plug and abandon injection or production wells at the end of the field life.

In case there is damage to the cement matrix and $CO_2$ starts to migrate, the self-healing capabilities that can be incorporated in EverCRETE system will repair the crack, reestablishing the integrity of the well and recovering zonal isolation.

EverCRETE system can also be used as a cement across potential $CO_2$-producing formations or as the primary barrier in the wellbore for in situ fluids after abandonment and permanent decommissioning.




*Compressive strength evolution of portland cement and EverCRETE system samples with time in wet supercritical $CO_2$ fluid and in $CO_2$ saturated in water at 194 degF [90 degC] under 28 MPa of pressure. After 6 months in $CO_2$-saturated water, the compressive strength of portland cement is not measurable because most of the samples are highly deteriorated. The stability of the EverCRETE system minimizes the degradation potential of the long-term barrier.*

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slb.com/EverCRETE

# Response to Specific Comments, SC-11 and SC-12

# Financial Assurance

# Updated Financial Assurance Demonstration Plan for Spirea I-1

## May 10, 2024

## 1.0 Financial Assurance Demonstration Plan

This Financial Assurance Demonstration Plan (FADP) was developed to meet the requirements of WYDEQ Chapter 24 **§26**. High Plains will maintain financial responsibility for all applicable phases of this project, including:

- Permitting/characterization;
- Testing and monitoring (pursuant to Chapter 24 **§20**);
- Operations, including injection and well-plugging (pursuant to Chapter 24 **§18** and **§23**);
- Post-injection site care; and
- Emergency and remedial response (pursuant to Chapter 24 **§25**).

The estimation of required coverage is provided for Spirea. The emergency and remedial response costs and the 2D seismic survey costs for the injection period and the post injection and site closure period were evaluated first as a total for the five injection wells and five monitoring wells listed in Table 1, and then assessed for the Spirea Project.

Table 1—Well names and location information for the wells included in the emergency and remedial response financial assurance cost estimation and total seismic cost estimation.

| **Project Wells** | |
|---|---|
| **Proposed Injection Wells** | **Proposed Deep Monitoring Wells** |
| Juniper I-1 | Juniper M-1 |
| Azalea I-1 | Azalea M-1 |
| Cypress I-1 | Cypress M-1 |
| Barberry I-1 | Barberry M-1 |
| Old Barberry I-1 | Old Barberry M-1 |
| **Spirea I-1** | **Spirea M-1** |

All costs included in this financial assurance cost estimate are third party costs. These costs will be updated annually to account for inflation costs and project-related changes.

## 1.1 Cost Estimation

A financial assurance cost estimate, based on current dollars, is provided in Table 2. Cost estimates for third party monitoring are provided in Tables 3-8.

Table 2 has been estimated for the following:

- Performing corrective action for all wells in the AoR that require it (as identified and approved by the Administrator)
- Plugging the injection well
- Post-injection site care (including plume stabilization, monitoring, measurement, verification, corrective action, and other actions needed, to ensure that USDWs are

not endangered from the time of well-plugging until site closure is certified by the Administrator and above ground-reclamation is completed) and site closure
- Testing and monitoring activities throughout the injection period
- Emergency and remedial response

Table 2—Summary of financial assurance cost estimations.

| Activity Estimated Total Cost | |
|---|---|
| Corrective Action on Wells in the AOR | $0 |
| Testing and Monitoring | $4,365,330 |
| Plugging of Spirea I-1 | $597,000 |
| Post-Injection Site Care and Facility Closure | $15,771,505 |
| Emergency and Remedial Response (including endangerment to USDWs) | $5,800,553 |
| **Total** | **$26,534,388** |

Table 3—Third Party Cost Estimate for Soil Gas Sampling

| Soil Gas Sampling Method | |
|---|---|
| Locations for Sampling | 1 |
| Time (Hours) | 4 |
| Labor ($125/hr) | $1000 |
| Tedlar Bags ($15/bag) | $75 |
| Lab Analysis | $1000 |
| Report Generation | $1000 |
| Equipment | Purchased Prior to Injection |
| **Total/ Occurrence** | **$2,575** |

Table 4—Third Party Cost Estimate for Ground Water Sampling

| Ground Water Monitoring | |
|---|---|
| Locations for Sampling | 1 |
| Total Ground Water Wells | 3 |
| Labor (purging and testing) | $10,000 |
| Lab Analysis | $5,000 |
| Truck Usage | $2,000 |
| Per Diem | $1,000 |
| Report Generation | $10,000 |
| Contingency | $20,000 |
| **Total/ Occurrence** | **$48,000** |

Table 5—Third Party Cost Estimate for Vegetation Survey and Continuous Air Monitoring

| **Annual Air Monitoring** | |
|---|---|
| Labor Field Coordination | $1,000 |
| Locations for Sampling | 1 |
| Labor (Monthly Inspections) | $1,548 |
| Truck Usage (Mob/Demob) | $1,400 |
| Per Diem (Mob/Demob) | $2,400 |
| Labor (Atmospheric Monitoring) | $1,585 |
| Vehicle Rental | $1,440 |
| Per Diem | $2,400 |
| Field Equipment and Supplies | $19,008 |
| Data Management | $2,400 |
| SQL Server License/ Month | $3,960 |
| Cloud Storage and Server | $1,901 |
| Report Generation | $2,110 |
| **Total/ Annum** | **$41,152** |

Table 6—Third Party Cost Estimate for Seismic Monitoring Program.

| **2D Seismic Monitoring** | |
|---|---|
| Miles Over 6 Well Scenario | 72 |
| Cost/ Mile | $39,000 |
| Seismic Total 6 Well Scenario | $2,800,000 |
| **Spirea I-1 Subtotal** | **$468,000** |

Table 7—Third Party Cost Estimate for Annual Well Testing and Monitoring Program.

| **Annual Injector Well Testing and Monitoring Program** | |
|---|---|
| Annular Pressure Test | $5,000 |
| DTS Fiber Optic Log | $30,000 |
| Mob/ Demob Wireline | $5,000 |
| Per Diem | $5,200 |
| Pulsed Neutron Log | $25,000 |
| Mob/Demob Cased Hole | $5,000 |
| Miscellaneous | $4,750 |
| **Spirea I-1 Subtotal/ Occurrence** | **$79,950** |

Table 8—Third Party Cost Estimate for Annual Well Testing and Monitoring Program.

| 5 Year Testing and Monitoring Program | |
|---|---|
| Annular Pressure Test | $5,000 |
| Temp Log, Static and Dynamic | $8,000 |
| Pressure Fall Off Test | $30,000 |
| DTS Fiber Optic Log | $30,000 |
| Mob/ Demob Wireline | $5,000 |
| Per Diem | $12,750 |
| Multiple Arm Caliper | $25,000 |
| Electro-magnetic Tools | $25,000 |
| Pulsed Neutron Log | $25,000 |
| Pulling Tubing and Running Tubing | $9,000 |
| Additional Rig Costs (Mob/ Demob) | $8,000 |
| Unit Charge Wireline/ Rig | $26,750 |
| Mob/ Demob Cased Hole | $5,000 |
| **Spirea I-1 Subtotal/ Occurrence** | **$214,500** |

### *1.1.1 Corrective Action*

No corrective action remediations are anticipated for the AoR.

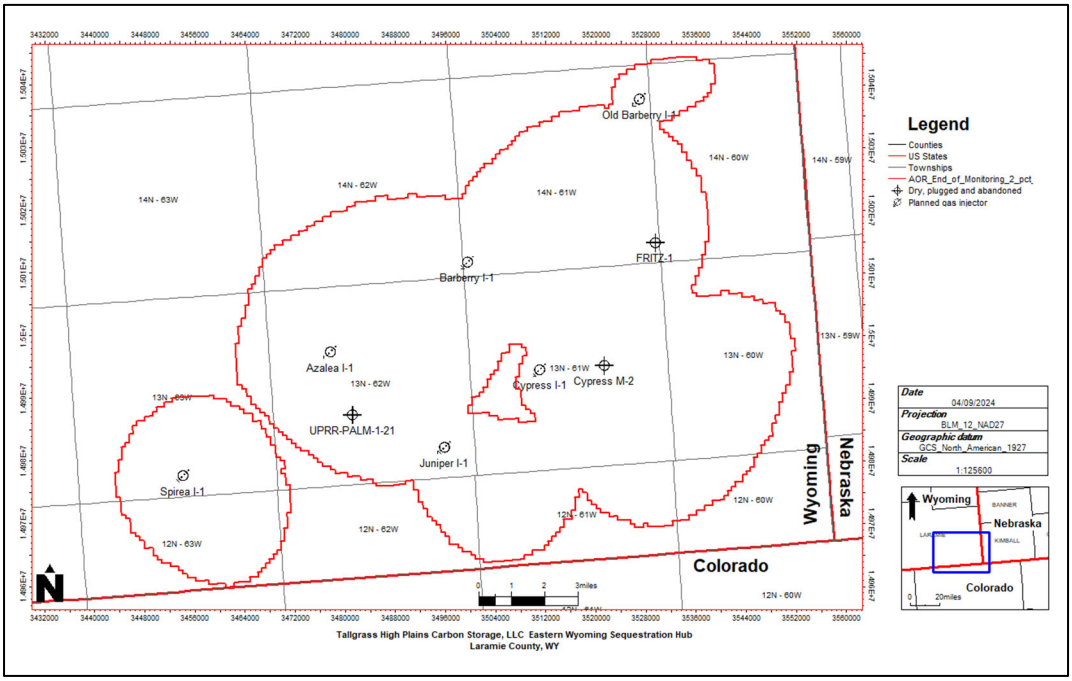


Figure 1. Map demonstrating that there are no penetrations (of the top seal or deeper) within the Spirea I-1 plume.

### *1.1.2 Testing and Monitoring during the Injection Period*

The cost estimates for the testing and monitoring for the project are included in Table 9. These costs are inclusive of the activities occurring during the modeled injection period of the Spirea I-1 outlined in the Testing and Monitoring Plan.

Table 9 — Financial assurance cost estimations for Testing and Monitoring

| **Injection Period Testing and Monitoring (15 years)** | |
|---|---|
| 2D Time-lapse Seismic Survey (1/6$^{th}$ of $2,808,000) | $468,000 |
| Soil Gas Monitoring | $77,250 |
| Groundwater Monitoring | $1,440,000 |
| Air Monitoring | $617,280 |
| Testing and Monitoring Logs | $1,762,800 |
| **Total** | **$4,365,330** |

### *1.1.3 Injection Well Plugging*

The cost estimate for the plugging of the Spirea I-1 is broken down in Table 10.

Table 10—Financial assurance cost estimations for injection well plugging.

| **Spirea I-1 P&A Cost Estimate** | | |
|---|---|---|
| Workover Rig | $ | 100,000 |
| Rental Tools | $ | 15,000 |
| Mud/Brine | $ | 10,000 |
| Frac Tanks | $ | 8,500 |
| Wireline | $ | 30,500 |
| Final Mechanical Integrity Test and Casing Logs | $ | 75,000 |
| Cement | $ | 210,000 |
| Bridge Plugs/Packers | $ | 75,000 |
| Casing Crew | $ | 15,000 |
| Miscellaneous | $ | 58,000 |
| **Total ($/well)** | **$** | **597,000** |

### *1.1.4 PISC and Site Closure*

The total associated PISC and site closure costs are described in Table 11. The site closure costs include plugging the Spirea M-1 as described in Table 12, and surface facility closure costs as described in Table 13. The cost for the 2D seismic was estimated to be one sixth of the total estimated seismic cost for a 2D seismic survey covering the total modeled plume area for the wells listed in Table 1.

Table 11—Financial assurance cost estimations for PISC and site closure.

| **Post-Injection Site-Care (65 years) and Facility Closure** | |
|---|---|
| **Monitoring** | |
| 2D Time-lapse Seismic Survey (1/6$^{th}$ of $2,808,000) | $468,000 |
| Soil Gas Monitoring | $167,375 |
| Ground Water Monitoring | $3,120,000 |
| Air Monitoring | $2,674,880 |
| Testing and Monitoring Logs | $5,411,250 |
| **Subtotal** | **$11,841,505** |
| **Operations and Maintenance of Monitoring Wells** | |
| **Subtotal** | **$2,808,000** |
| **Spirea M-1 Plugging** | |
| **Plugging Subtotal** | **$522,000** |
| **Surface Facilities Closure** | |
| **Subtotal** | **$600,000** |
| **PISC and Facility Closure Total** | |
| **Total** | **$15,771,505** |

Table 12—Financial assurance cost estimations for monitoring well plugging.

| Spirea M-1 P&A Cost Estimate | | |
|---|---|---|
| Workover Rig | $ | 100,000 |
| Rental Tools | $ | 15,000 |
| Mud/Brine | $ | 10,000 |
| Frac Tanks | $ | 8,500 |
| Wireline | $ | 30,500 |
| Final Mechanical Integrity Test and Casing Logs | $ | 75,000 |
| Cement | $ | 210,000 |
| Casing Crew | $ | 15,000 |
| Miscellaneous | $ | 58,000 |
| Subtotal ($/well) | **$** | **522,000** |

Table 13—Post-Injection Site Care Ops and Closure.

| Post Injection Site-Care- Ops and Closure | |
|---|---|
| | |
| Annual Labor Costs | $30,000 |
| Annual Ops Costs (utilities, equipment, etc.) | $10,000 |
| Annual Miscellaneous & Contingency | $3,200 |
| Surface Remediation | $120,000 |
| Road Remediation | $120,000 |
| Surface Equipment Removal | $120,000 |
| Pipeline Flushing and Abandonment in Place | $120,000 |
| Additional Miscellaneous & Contingency | $120,000 |
| Subtotal ($/well) | **$ 643,200** |

### *1.1.5 Emergency and Remedial Response*

The Emergency Remedial Response (ERR) Financial Assurance Costs estimation was performed by Industrial Economics, Inc. (IEc) and the summary of the Monte Carlo outputs, including the total maximum per occurrence ERR cost estimate is provided in Table 14. The maximum per occurrence cost estimate across 50,000 trials was $5,800,553. The estimate was calculated per the requirements of Chapter 24 §25. IEc believes this estimate to be reasonable and appropriately conservative for emergency and remedial response involving event-based occurrences in the project location. The basis for the IEc cost estimates is discussed in greater detail in the report included in Exhibit 1 in the Response to Comments Attachments.

Table 14—Financial assurance cost statistical outcomes for emergency and remedial response.

| Emergency and Remedial Response Cost Estimation | |
|---|---|
| Average | $311,304 |
| Standard Deviation | $565,211 |
| 5th Percentile | $0 |
| 50th Percentile | $0 |
| 95th Percentile | $1,520,369 |
| 99th Percentile | $2,379,064 |
| Minimum | $0 |
| Maximum | $5,800,553 |
| **Total (per occurrence maximum)** | **$5,800,553** |

## 1.2 Financial Assurance Instruments

The financial assurance instruments will be submitted during the application phase of the project and on the required forms.

### *1.2.1 Instrument Funding*

The costs outlined in the Cost Estimation section above have been broken into the anticipated phases of funding in Tables 15 and 16.

Table 15- Financial Assurance Components and Costs – Pre-injection and year 1 of Injection

| Financial Responsibility Element | Cost Estimate | When Funded |
|---|---|---|
| A. Corrective Action: | $0 | Prior to well construction |
| B. Injection Well Plugging | $597,000 | Prior to well construction |
| C. PISC and Site Closure – Monitor Well | $3,330,000 | Prior to well construction |
| D. PISC and Site Closure – Site Remediation | $600,000 | Prior to well construction |
| E. PISC Testing & Monitoring | $11,841,505 | Prior to well construction |
| **Total Cost Prior to Well Construction:** | | **$16,368,505** |
| F. Emergency and Remedial Response (prorated per plume) | $5,800,553 | Prior to Authorization to Inject |
| **Total Cost Prior to Authorization to Inject:** | | **$5,800,553** |
| G. Operation and Maintenance During Testing and Monitoring – Injection Period | $291,022 | After one (1) year of injection |
| **One (1) Year After Injections Begin:** | | **$291,022** |

Table 16- Financial Assurance Components and Costs – year 2 through 15 of injection period

| Financial Responsibility Element | Cost Estimate | When Funded |
|---|---|---|
| Financial Responsibility Element - years 2-15 | Cost Estimate | When Funded |
| Operation and Maintenance During Testing and Monitoring – Injection Period | **$4,074,308** | Within thirty (30) days of the anniversary date of submittal of original financial assurance. |
| **Total Cost for year 2-15 of Injection:** | | **$4,074,308** |

### *1.2.2 Public Liability Insurance*

High Plains will obtain and maintain public liability insurance for the Spirea I-1 and associated facilities to meet the requirements of Wyoming Statutes **§35-11-313(f)(ii)(O)** and WYDEQ Chapter 24 **§26(l)(i)(B)**. Such policy will identify each facility by name, address, and EPA Identification Number as well as identify the amounts and types of coverage for each facility. The policy will be arranged by Marsh USA LLC, a subsidiary of Marsh McLennan, and provided by Ascot. A CCS Support Letter is provided in Exhibit 2 in the Response to Comments Attachments. The specimen policy and certificate of insurance from Ascot are provided in Exhibit 3 in the Response to Comments Attachments.

### *1.2.3 Surety Bond*

Sompo International has confirmed that High Plains will be able to obtain a surety bond for the coverage of the remaining financial assurance items, per the letter provided in Exhibit 4 in the Response to Comments Attachments. High Plains is still determining what form of financial assurance will be used to cover the ERR but will have that secured prior to the authorization to inject.

# APPENDIX A—FINANCIAL DEMONSTRATION PLAN

Exhibit 1—Cost Estimates for Emergency and Remedial Response Section and Event-Based Risk Activities

Exhibit 2—Pollution Support Letter – Marsh

Exhibit 3—Specimen Policy and Certificate

Exhibit 4—Surety Bond Letter - Sompo International

*29 February 2024*

# Tallgrass Energy Eastern Wyoming Sequestration Hub Project

## Written Financial Assurance Cost Estimates in Support of:

Section 26(b)(i)(E) Emergency and Remedial Response

Section 26(b)(ii)(A)-(G) Event-Based Risk Activities
*(Risks 1 through 7 of the Risk Activity Table in Appendix A of Chapter 24)*

**Prepared for:**

**Tallgrass Energy**

**Eastern Wyoming Sequestration (EWS) Hub Project**

**Prepared by:**

**Industrial Economics, Inc.**

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## 1.0 INTRODUCTION

This report provides written Financial Assurance Cost Estimates for the Eastern Wyoming Sequestration Hub located in Laramie, Wyoming which will comprise five Class VI injection wells (hereinafter, EWS Hub Project).[1] The estimates conform to the regulatory requirements promulgated at Wyoming Water Quality Rules (WWQR) Chapter 24: Section 26(b)(i)(E) Emergency and Remedial Response, and Section 26(b)(ii)(A)-(G) Event-Based Risk Activities (Risks 1 through 7 of the Risk Activity Table in Appendix A of Chapter 24).[2] These estimates are intended to inform the face amount of financial assurance(s) necessary to satisfy emergency and remedial response actions, and the stated event-based risk activities summarized in Appendix A of Chapter 24.[3,4] For the avoidance of doubt, this document does **not** include costs associated with corrective action, well plugging and abandonment, post-injection site care or site closure (including removal of above-ground facilities and site reclamation) in the estimation of ERR response costs. All such costs are addressed elsewhere in the Tallgrass Class VI permit application.

Estimating financial assurance cost estimates for possible emergency and remedial responses, as well as actions to address the event-based risk activities contemplated in Appendix A of Chapter 24 necessitates understanding of the interactions between the carbon capture and underground storage (CCUS) stream, the geophysical environment in which it will be stored, and nearby populations. The long-term nature of such projects, the low (but not zero) probability of a release event occurring that may require emergency and remedial response, variability in potential incident conditions at the site, the size of the potentially impacted population, and likely exposure pathways (among other factors) inform the following emergency and remedial response cost estimates.

As described in more detail below, we combine readily available information with the results of Monte Carlo analysis tailored to project-specific risks and uncertainties to generate reasonable upper bound estimates of financial assurance costs related to emergency and remedial response and WWQR event-based risk activities.

---

[1] The EWS Hub Project comprises the following five injection wells: Juniper I-1, Azalea I-1, Cypress I-1, Barberry I-1 and Old Barberry I-1 at latitude/longitudes (NAD83): 41.055976, -104.272853; 41.101266, -104.334272; 41.086491, -104.214625; 41.135708, -104.251332; and 41.200677, -104.144977 (respectively). The resulting estimates of ERR coverages relate to risk-based event activities arising within the project AOR, and have not been scaled to individual injection wells.

[2] Per WWQR Chapter 24, Section 26(b)(iii) and Appendix A, Risk Activity Table, cost estimation for "Major Risk" 1 through 7, as listed in Appendix A of WWQR, can be found in the following sections of this report: Section 7.5 (Risk 1 Mineral Rights Infringement), Sections 7.1 and 7.2 (Risk 2 Water Quality Contamination), Sections 7.3 and 7.4 (Risk 3 Single Large Volume CO2 Release to Surface and Risk 4 Low Level CO2 Release to Surface), Section 7.7 (Risk 5 Storage Rights Infringement), Section 7.6 (Risk 6 Modified Surface Topography Resulting in Property/Infrastructure Damage), and Sections 7.1 and 7.2 (Risk 7 Entrained Contaminant (Non-CO2) Releases). As we understand from the project developer, Risk 8 (Accidents/Unplanned Events (Typical Insurable Events) is addressed through the company's general liability insurance coverages, and therefore are not separately quantified in this report for purposes of ERR cost estimation.

[3] Per WWQR Chapter 24, Section 26(b), financial assurance cost estimates (including those that address emergency and remedial response) must be updated annually, or within 60 days of receiving notice that the Administrator has determined that a demonstration of financial assurance is not adequate. Consistent with Section 25(a)(i) and (a)(ii) requirements, ERR cost estimates also will need to be reevaluated after any updates to the emergency and remedial response plan.

[4] In general, because "accidents and unplanned events" are typical insurable events that are covered through the company's general liability coverages, they are not addressed further in this analysis. Financial assurance cost estimates for well capping and permitted abandonment, and removal of above-ground facilities and site reclamation are addressed elsewhere in the Tallgrass submission, and therefore are not addressed further in this analysis.



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Importantly, model results will vary with factors that would be expected to impact project risk, such as: the purity of the sequestration stream and degree to which any co-contaminants might result in additional emergency response challenges; the duration of injection and post-injection site care activities; the number of wells present in the Area of Review (AOR) that extend below USDWs and the proportion that penetrate caprock; population density and the type/extent of private water well use; the presence and size of community/municipal water systems; and the use and length of new pipelines to transport captured CO2 to injection well locations. In our view, the following analyses and resulting cost estimates provide a reasonable, conservative, and objective basis for determining the face amount of financial assurance instrument(s) necessary to support a Class VI permit consistent with Wyoming regulation.

The cost estimation method applied to the EWS Hub Project is based on the peer-reviewed approach pioneered by Industrial Economics, Incorporated ("IEc"); this approach has been used to inform estimation of emergency and remedial response costs in previously approved Class VI permits.[5] IEc tailored the valuation parameters of its Carbon Capture and Storage stochastic Monte Carlo model ("CCSvt model") to reflect site-specific factors associated with the EWS Hub Project. Specifically, the model's input parameters reflect the geologic location and specific chemical composition of the project's CCUS stream, as well as site-specific conditions that exist within the established area of review. The analysis adopts several conservative input assumptions and incorporates probabilistic calculations that allow for multiple release incidents through operation and post-injection site care. Cost estimates are based upon generally accepted actions to address the types of events identified in WWQR Chapter 24 Section 26(b)(ii) and the Risk Activity Matrix identified in Section 26(b)(iii) and supported by WWQR Chapter 24 Appendix A.

Based on a model run of 50,000 Monte Carlo trials **we estimate an upper-bound financial assurance cost estimate to satisfy emergency and remedial response and WWQR event-based risk activities of $9.4 million in current 2023 dollars.** This upper-bound cost estimate reflects the single Monte Carlo trial with the greatest financial assurance costs out of the 50,000 trials run. We believe this estimate to be reasonable and appropriately conservative. In the sections that follow, we discuss the basis for our cost estimates in greater detail.

## 2.0 WWQR CHAPTER 24 SECTION 26: FINANCIAL ASSURANCE COST REQUIREMENTS

The Wyoming regulations promulgated under Chapter 24 Section 26 require demonstration of financial responsibility, and specifically that owners or operators of Class VI wells establish, demonstrate, and maintain financial responsibility for emergency and remedial response pursuant to Section 25 of the Chapter. In deriving the financial assurance cost estimate, owners and operators of Class VI wells must consider the Risk Activity Matrix in Appendix A of Chapter 24, which includes the following array of event-based risk activities:

A. Contamination of underground sources of water including, drinking water supplies;
B. Mineral rights infringement;

[5] This approach informed the ERR coverage estimates for the Class VI permits in North Dakota, including for example, Dakota Gasification Company (Case No. 29450), Red Trail Energy, LLC (Case No. 28848) and Blue Flint Sequester Company, LLC (Case No.: 29888). See Trabucchi, C., Donlan, M., Sprit, V., Friedman, S. and Esposito, R., 2014, 'Application of a Risk-Based Probabilistic Model (CCSvt Model) to Value Potential Risks Arising from Carbon Capture and Storage', Energy Procedia 63 (2014) 7608-7618, https://www.sciencedirect.com/science/article/pii/S1876610214026101. See also Trabucchi, C., Donlan, M. and Wade, S., 2010 'A Multi-Disciplinary Framework to Monetize Financial Consequences Arising from CCS Projects and Motivate Effective Financial Responsibility', International Journal of Greenhouse Gas Control 4 (2010) 388-395, https://www.sciencedirect.com/science/article/abs/pii/S1750583609001108. See also Trabucchi, C., Donlan, M., Huguenin, M, Konopka, M., Bolthrunis, S., 2012, Valuation of Potential Risks Arising from a Model, Commercial-Scale CCS Project Site: Prepared for GCCSI and the CCS Valuation Sponsor Group, June 1, 2012, https://www.globalccsinstitute.com/archive/hub/publications/40831/iec2012valuationofpotentialrisks.pdf.

C. Single large-volume release of carbon dioxide that impacts human health and safety or that causes ecological damage;
D. Low-level leakage of carbon dioxide to the surface that impacts human health and safety or that causes ecological damage;
E. Storage rights infringement;
F. Property and infrastructure damage, including changes to surface topography and structures;
G. Entrained contaminant releases of contaminants other than carbon dioxide;
H. Accidents and unplanned events;
I. Well capping and permitted abandonment; and
J. Removal of above-ground facilities and site reclamation.

This report focuses on financial assurance cost estimation for Section 26(b)(i)(E) Emergency and Remedial Response, and Section 26(b)(ii)(A)-(G) Event-Based Risk Activities – Risks 1 through 7 of the Risk Activity Table in Appendix A of Chapter 24, (hereinafter WWQR event-based risk activities). As previously noted, because "accidents and unplanned events" are typical insurable events separately covered through the company's general liability coverages, they are not addressed further in this section. The exception are accidents and unplanned events that may endanger an underground source of drinking water, or threaten human health, safety, or the environment. In addition, financial assurance cost estimates for well capping and permitted abandonment (I), and removal of above-ground facilities and site reclamation (J) are addressed elsewhere in the Tallgrass submission, and therefore are not addressed further in this report.

## 3.0 MONTE CARLO APPROACH TO FINANCIAL ASSURANCE COST ESTIMATION

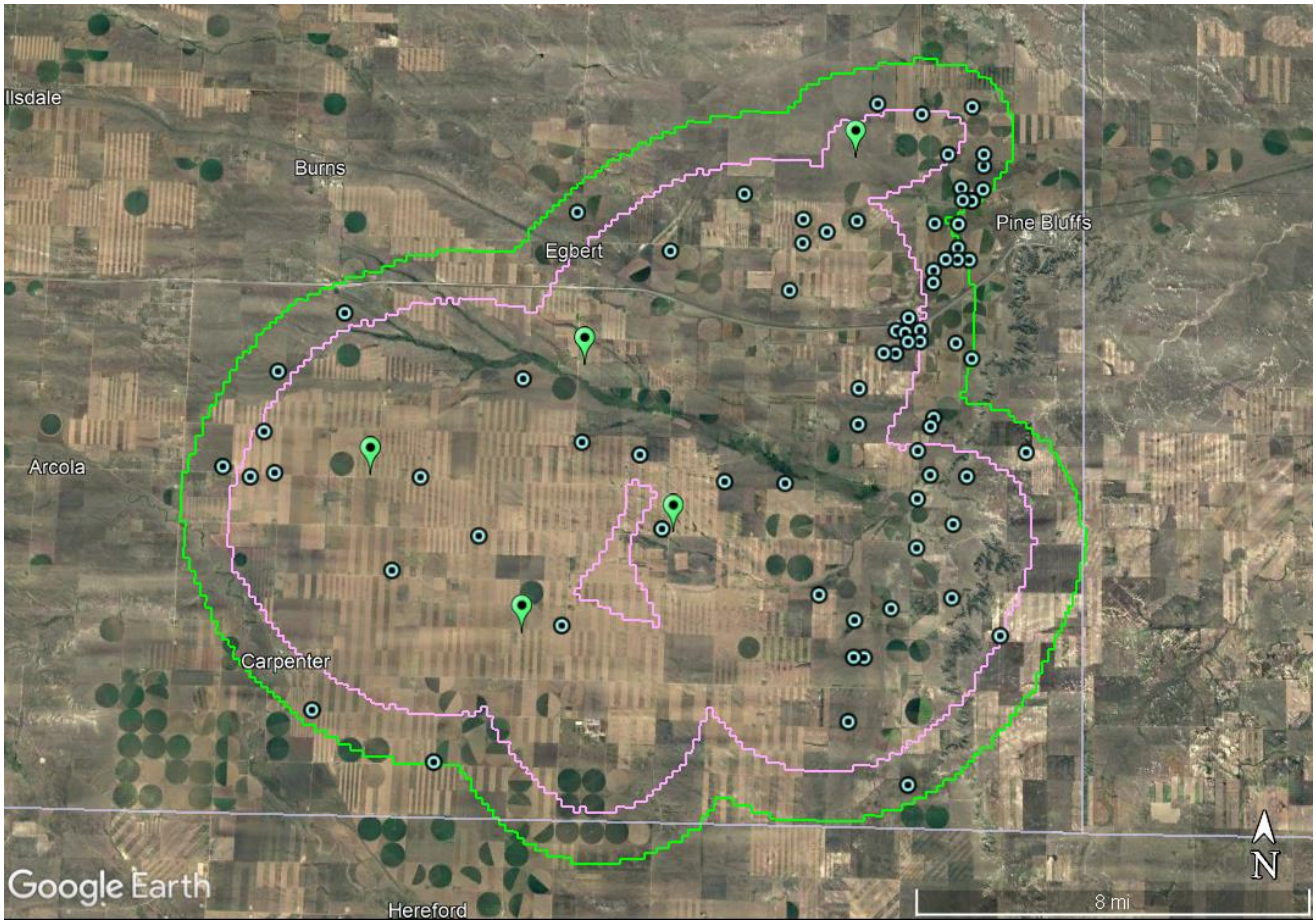
We estimate the cost of emergency and remedial response actions and WWQR event-based risk activities by tailoring the valuation parameters underpinning the CCSvt model to reflect site-specific factors associated with the EWS Hub Project. The CCSvt model published in the peer-reviewed technical literature leverages Monte Carlo (i.e., risk-based, probabilistic) modeling and site-specific scenario analysis (Trabucchi et al., 2014). In our view, Monte Carlo analysis is particularly well suited to the evaluation of potential costs arising from low probability events over long periods of time. As described in Trabucchi et. al (2014), key parameters which inform the CCSvt model inputs include identification of release event types and probabilities, the duration of injection and post-injection/site closure (PISC) activities, and cost distributions for anticipated response actions if ERR incidents or WWQR event-based risk activities occur.

This approach is explicitly consistent with WWQR Chapter 24 Section 26 (b)(iv) requirements, which state: "*the financial assurance cost estimate shall be based upon a multi-disciplinary analytical framework such as Monte Carlo or other commonly accepted stochastic modeling tools*." The section goes on to state that: "*cost curves shall combine risk probabilities, event outcomes, and damages assessment to calculate expected losses under a series of events;*" and, "*for all cases of potential damages, the probability distributions should be identified for 50 percent, 95 percent, and 99 percent probabilities of occurrence*." The analyses underpinning this report conform to these requirements.

## 4.0 AREA OF REVIEW

Consistent with WWQR Chapter 24 Section 26(b)(7), the information and analyses underpinning the estimation of financial assurance costs reflect the AOR for the EWS Hub Project, as shown in Exhibit 1 (delineated by the green line). Exhibit 1 also reflects the maximum extent of the CO2 plume, critical pressure increase, or the maximum combination of the two (shown by the purple line) and incorporates a one mile buffer (delineated by the green line). For context, Exhibit 1 also shows the location of the five injection wells (green tear drops) that comprise the EWS Hub Project, as well as adjacent oil and gas wells (blue circles).

**Exhibit 1. Area of Review**




## 5.0 DURATION OF INJECTION AND POST-INJECTION SITE CARE (PISC) ACTIVITIES

The financial assurance cost estimates reflect: (1) a 30-year CO2 injection period, (2) a 50-year PISC period, and (3) the possibility of having to address risk-based event activities that potentially could occur during the operational and PISC project phases, necessitating emergency and remedial response action.[6] Consistent with these assumptions, the Monte Carlo calculations incorporate an overall project timeline of 80 years (i.e., 30 years of injection, plus 50 years of PISC). Financial assurance cost estimates are provided for the entirety of the project timeline, as well as by project phase.

## 6.0 RISK EVENT TYPES AND PROBABILITIES

### 6.1 Leakage through Wells, Caprock, and Faults

Exhibit 2 identifies the risk event types and probabilities used to estimate emergency and remedial response costs arising from well leaks and leakage through caprock, existing faults and induced faults. We base annual release probabilities on the Final Risk Assessment Report for the FutureGen Project Environmental Impact Statement, revised April 2007.[7] These data reflect extensive, federally-funded analysis, are publicly available, and informed the U.S. Department of Energy's development of an Analog Site Database regarding the release of CO2 from existing injection sites and natural releases.[8] The Analog Site Database includes information from

[6] Information provided by the project sponsor indicates that the injection periods for the individual injection wells will vary, but none will exceed 30 years.
[7] See https://www.energy.gov/sites/prod/files/EIS-0394-DEIS-RiskAssessmentReport-2007.pdf, p. 6-15, Table 6-11.
[8] Ibid, pg 5-1.

four existing CCUS sites, 16 natural CO2 sites in sedimentary rock formations, and 17 sites in VHM (volcanic, hydrothermal, and metamorphic) areas. These sites have been identified in several natural analog investigations for CCUS. In addition to leakage from reservoirs via natural pathways, the FutureGen efforts considered leakage information from myriad CCUS risk assessments and developed a well failure-release event database, which reflects applied experience from the natural gas storage industry, the oil and gas industry, and wells at natural CO2 reservoirs.

In our view, absent event data arising from recently permitted CCUS projects in North America, the FutureGen databases offer an objective, reasonable basis for determining annual probabilities.[9] Although carbon dioxide enhanced oil recovery (CO2 EOR) is a technique used to recover oil from mature fields that may no longer be productive through traditional recovery methods, to our knowledge, there are no systematic studies of real world frequencies of CO2-related emergency and remedial response events that could be used to augment the FutureGen analyses.[10]

Estimates of potential consequences for the EWS Hub Project are informed by the annual probability point estimates resulting from the FutureGen efforts. In some cases, FutureGen provides a range of probabilities – in such circumstances, we conservatively use the highest probability in the range. Exhibit 2 reflects the release probabilities for eight types of event-based risk activities.[11] For well-related events, the identified probabilities reflect the risk of release for a single well.

As previously noted, five injection wells are planned for the EWS Hub Project (see Exhibit 1). As noted elsewhere in the permit application, Tallgrass has determined that there are three 'deep' (i.e., deep enough to penetrate the injection zone) oil & gas wells in the AOR. However, for purposes of the Monte Carlo calculation, we conservatively assume the presence of two undocumented 'deep' oil & gas wells in the AOR. We believe that doing so provides a buffer against the possibility that records may be incomplete, and construction or natural landscape features may obscure old well locations.[12]

The project sponsor has identified 81 'shallow' (i.e., not deep enough to penetrate the injection zone) oil & gas wells in the AOR. Our Monte Carlo calculations conservatively assume the presence of eight additional undocumented shallow wells.[13] We add these wells for the same reasons discussed above – a buffer against the possibility of incomplete records – resulting in a total of 89 shallow oil & gas wells for purposes of estimating consequences arising from WWQR event-based risk activities. Finally, we include the five anticipated above-

[9] Notably, since development of the FutureGen analysis, the Arthur Daniels Midland (ADM) site in Decatur, IL was granted a Class VI permit by EPA to inject CO2 into the subsurface environment for purposes of permanent carbon capture and storage. Publicly available information suggests that, over the last decade, ADM has safely and permanently stored more than 3.5 million metric tons of CO2 at its commercial CCS site in Decatur, IL. See: https://www.adm.com/en-us/standalone-pages/adm-and-carbon-capture-and-storage/. To our knowledge, none of the more recently permitted CCS projects in North America are operational and actively injecting CO2 for permanent subsurface storage. Further, off-shore analogs such as Sleipner, do not appear to offer corresponding storage characteristics and attendant risk profiles that are akin to the system contemplated by the EWS Hub Project. In our view, relying on such analogs do not offer a necessarily more reasonable basis for determining annual probabilities than the FutureGen databases.

[10] See for example Porse, Sean, Sarah Wade and Susan Hovorka "Can we Treat CO2 Well Blowouts like Routine Plumbing Problems? A Study of the Incidence, Impact and Perception of Loss of Well Control" Energy Procedia 63 (2104) 7149 – 7161, which notes that "There are no standard formats for reporting loss of control events at the Federal or state level; consequently, many states have varying levels of accessibility for reporting ranging from relatively organized to completely unavailable. With such a wide degree of reporting standards, it was difficult to gather the desired data" (pg. 7154).

[11] Specified risk events could occur for a variety of reasons, including but not limited to mechanical failure, industrial activities unrelated to CCUS, incomplete/inaccurate subsurface characterization, natural or induced seismicity, other natural subsurface processes. Every WWQR event-based risk activity that occurs in the Monte Carlo analysis, whatever its underlying cause, is assumed to require an emergency and remedial response action.

[12] This adjustment for unknown wells is based on professional judgement, informed by the fact that Tallgrass has identified approximately 84 oil & gas wells in the AOR, three of which extend to depths sufficient to penetrate the injection zone.

[13] This adjustment for unknown wells is based on professional judgement, reflecting a 10% increase relative to the number of known wells.

zone monitoring wells planned for the project in the 'shallow well' category, yielding a total shallow well count of 94.

The FutureGen efforts do not provide release probability estimates for 'shallow' wells, as defined and identified for purposes of the Monte Carlo calculation. As such, we assume that shallow wells that do not penetrate the caprock have a release probability equal to twice the highest probability for caprock or fault release events. This assumption reflects the fact that CO2 or brine would need to escape through the caprock or fault before reaching the shallow well, at which point the well may yield a more direct pathway to a USDW. We believe this approach is reasonable and conservative.

Because in-zone monitoring wells necessarily penetrate caprock and confining layers and extend to the surface, they represent potential conduits for CO2 injectate and/or formation brines. For completeness, the Monte Carlo model used to monetize consequences necessitating emergency and remedial response actions can incorporate deep CO2 monitoring wells for purposes of ERR cost estimation. To do so, we conservatively assign an annual release probability to in-zone monitoring wells equal to that used for CO2 injection wells. This approach is likely to realize a conservative output given that monitoring wells are not subject to the same type or extent of use as injection wells. Importantly however, as we understand, no in-zone monitoring wells are anticipated for the EWS Hub Project. As such, although the capability to evaluate and model the consequences of this potential risk conduit exists, we have not done so because such wells are not anticipated by the project sponsor.

### Exhibit 2. Probabilities for Well, Caprock and Fault Leakage Events

| Risk Event Type | Annual Probability | Number of Wells |
|---|---|---|
| Deep Oil & Gas Well Leak | 0.1% per well[a] | 5 |
| CO2 Injection Well Leak | 0.001% per well[b] | 5 |
| Deep CO2 Monitoring Well Leak | 0.001% per well[c] | 0 |
| Rapid Leakage Through Caprock | 0.00000002%[d] | n/a |
| Slow Leakage Through Caprock | 0.004%[e] | n/a |
| Release Through Existing Faults | 0.000002%[f] | n/a |
| Release Through Induced Faults | 0.000002%[g] | n/a |
| Leakage Through Caprock/Faults then Shallow Well | 0.008%[h] | 94 |

Source for risk events and annual probabilities: Final Risk Assessment Report for the FutureGen Project Environmental Impact Statement, revised April 2007, available online at: https://www.energy.gov/sites/prod/files/EIS-0394-DEIS-RiskAssessmentReport-2007.pdf, p. 6-15, Table 6-11.

Additional Notes:

a) Highest probability within FutureGen range for undocumented deep wells developed from the FutureGen analog database.
b) Highest probability within FutureGen range for CO2 injection wells developed from the FutureGen analog database.
c) Conservatively assumed to be equal to CO2 injection well leak probability.
d) Equal to FutureGen probability for rapid leakage through caprock developed from the FutureGen analog database.
e) Equal to FutureGen probability for slow leakage through caprock developed from the FutureGen analog database.
f) Equal to FutureGen probability for release through existing faults developed from the FutureGen analog database.
g) Equal to FutureGen probability for release through induced faults developed from the FutureGen analog database.
h) Conservatively assumed to be twice as likely as the highest caprock/fault probability.

## 6.2 Pipeline Releases

The Monte Carlo calculations underpinning this cost estimation exercise include potential costs associated with the new, 'feeder' CO2 pipeline(s) that will connect the existing Trailblazer pipeline to the EWS Hub Project

CO2 injection wells. [14]The annual pipeline release probability used in the model is based on U.S. Department of Energy Pipeline and Hazardous Materials Safety Administration (PHMSA) data for CO2 pipeline release incidents. PHMSA has compiled pipeline incident data since 2002. In 2020, there were approximately 5,100 miles of CO2-carrying pipeline in the U.S., up from about 3,400 miles in 2004. There were 103 CO2 pipeline accidents recorded from 2002 through 2021. Those figures result in an annual release probability of 0.12% per pipeline mile. It is our understanding that approximately 34 miles of new CO2 pipeline currently are anticipated for the EWS Hub Project. The added feeder pipeline is to allow for transport of the CCUS stream from the existing Trailblazer pipeline to each injection well location. A reasonably conservative 4.08% annual pipeline release probability is used in this analysis.[15]

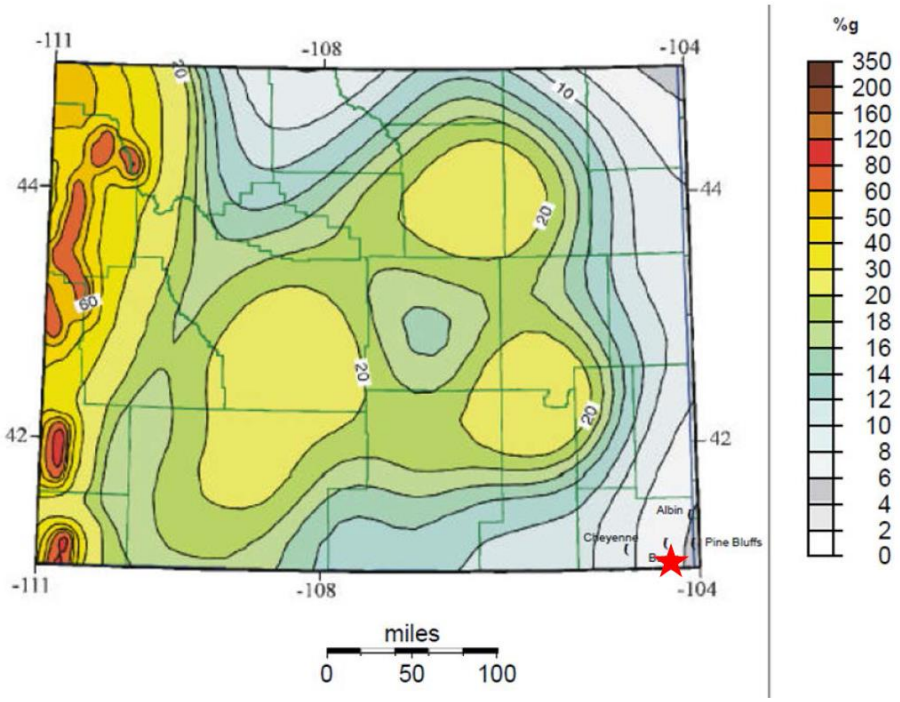
## 6.3 Induced Seismicity

We have been unable to identify any record of induced seismic events in the EWS Hub Project area. The project sponsor conducted an evaluation of seismic activity for Laramie County, which indicates that the project is in an area of low seismic activity. Exhibit 3 shows that the project (represented by the red star) is located in the 2% probability of exceedance in 50 years (grey zone) with a range from 5% to almost 14% peak ground acceleration in southeastern and northwestern Laramie County, respectively. As described in more detail in Section 7.6 of this document, this level of peak ground acceleration (5% to 14%) is the minimum scale of seismic event anticipated to cause measurable damage to surface infrastructure.

Induced seismicity of sufficient magnitude to potentially damage infrastructure most commonly occurs in areas with a history of extensive deep injection of fluids from nearby oil and gas operations.[16] As described throughout this document, the project AOR has a limited history of oil and gas development. Regardless, for financial assurance cost estimation purposes, we conservatively assume a probability and magnitude of induced seismic events equal to that for 'natural' seismic events. A 2% probability of exceedance in 50 years translates to an annual exceedance probability of 0.04%.[17]

[14] Potential release events associated with the existing Trailblazer pipeline are subject to regulatory, permitting, and financial assurance coverage requirements separate and distinct from this Class VI permit application. As such, risk events associated with the main Trailblazer pipeline are excluded from further analysis in this report.
[15] 4.08% EWS Hub Project pipeline annual release probability = 0.12% release probability per CO2 pipeline mile * approximately 34 miles of new pipeline.
[16] See, for example, Rubinstein, Justin and Alireza Babaie Mahani. Myths and Facts on Wastewater Injection, Hydraulic Fracturing, Enhanced Oil Recovery and Induced Seismicity. Seismological Research Letters. July 2015.
[17] 0.04% annual seismic probability = 2% seismic probability over 50 years / 50 years.

**Exhibit 3. USGS 2,500-year Probabilistic Acceleration Map of Wyoming***




*Map contours represent a 2% probability of exceedance in 50 years.

## 6.4 Pore Space Trespass

As described elsewhere in the Tallgrass Class VI permit application materials, the project sponsor has made substantial progress obtaining pore space rights. Through the pore space unitization process, the sponsor anticipates that it will have acquired pore space rights for all subsurface areas in which injected CO2 from the five injection wells is expected to reside.

Based on extensive subsurface data collection, site characterization, and plume modeling efforts, the sponsor believes it is unlikely that stored CO2 will migrate to other subsurface locations. The actual movement of CO2 in the subsurface environment will be calibrated with modeled predictions on a regular and systematic basis, and therefore it is likely that any potential trespass issue would be identified prior to occurrence and the amount and/or location of ongoing CO2 injection potentially adjusted to reduce or eliminate the trespass concern. Nevertheless, for purposes of deriving a financial assurance cost estimate, we conservatively assume a 10 percent chance that trespass occurs at some point during injection and/or PISC periods, and that such trespass will necessitate a response action. Specifically, the project sponsor's site characterization efforts indicate a substantially low likelihood of trespass. To ensure that the likelihood of trespass remains low, the sponsor anticipates closely monitoring the storage plumes as injection occurs; and, to the extent necessary, will adjust injection volumes and/or rates of injection if any risk of trespass emerges. Finally, after injection ends, current site characterization analyses suggest that pressure gradients will quickly dissipate, limiting the potential for plume movement and trespass during the PISC period. Regardless, for the avoidance of doubt, and in the interest of deriving a conservative estimate for purposes of ERR financial assurance coverages, we apply a 10% likelihood of trespass occurrence based on professional judgment.

## 7.0 COST DISTRIBUTIONS APPLIED TO EVENT-BASED RISK ACTIVITIES NECESSITATING EMERGENCY AND REMEDIAL RESPONSE ACTION

Previously peer-reviewed, published applications of the CCSvt model relied on 10,000 Monte Carlo trials. In the interest of reasonable conservatism, and for purposes of demonstrating financial responsibility in support of the Class VI permitting process, this analysis relies on 50,000 Monte Carlo trials. In our view, the reliance on 50,000 Monte Carlo trials offers an additional measure of conservatism and certainty. If a release from a WWQR event-based risk activity occurs during a Monte Carlo trial, the model randomly chooses a cost amount from the indicated cost distributions.

### 7.1 Well Repair Cost Distribution

Injection Well, Deep Monitoring Well, and Non-Project Deep Well repair cost distribution is as follows:

- Minimum: $5,000
- 10th percentile: $25,000
- Median: $62,000
- 90th percentile: $140,000
- Maximum: $1,700,000
- Burr Distribution[18]

Shallow Well repair cost distribution is as follows:

- Minimum: $5,000
- 10th percentile: $8,100
- Median: $56,000
- 90th percentile: $170,000
- Maximum: $500,000
- Exponential Distribution

We apply the above cost distributions to all well release incidents that occur in the Monte Carlo trials to stop leaks and prevent reoccurrence. For the EWS Hub Project analysis, we conservatively assume that addressing a well-related release of CO2 would involve plugging and surface reclamation.[19] As a proxy for such costs, we rely on information and analysis provided in Raimi et al (2021).[20] This peer-reviewed, publicly available analysis provides cost estimates for plugging and surface reclamation of oil and gas wells, based on data from five states (Montana, New Mexico, Kansas, Texas and Pennsylvania).[21]

For 'deep' wells (extending more than 4,000 feet below the surface), we use a Burr distribution in which the 10th percentile, median, and 90th percentile costs align with those found for high cost (and generally deepest) wells in Raimi et al., (2021). We conservatively set the minimum cost to $5,000, notwithstanding the fact that costs below this amount were observed in the data set. We set the maximum cost to $1.7 million, consistent

[18] The Burr distribution is commonly used to fit non-normally distributed data characterized by a right-skewed distribution (i.e., most values are clustered around the left tail of the distribution while the right tail of the distribution is longer).
[19] Plugging and surface reclamation are the most likely response measures to address a release from any inactive wells in the AOR. If an active CO2 injection well, monitoring well or industrial well was the source of a release, we assume that funds described in this section would be used to support well repair.
[20] Raimi, Daniel, A. Krupnik, J-S Shah, A. Thompson. "Decommissioning Orphaned and Abandoned Oil and Gas Wells: New Estimate and Cost Drivers. Environ. Sci. Technol. 2021, 55, 10224-10230.
[21] To our knowledge, there is no systematic, detailed information repository on well repair costs specific to Wyoming. In the absence of such data, we rely on the entire Raimi et al., data set so as to ensure robust, conservative cost estimation. We explored available cost data associated with orphan wells plugged by the Wyoming Oil and Gas Conservation Commission orphan well program; these Wyoming-specific data reveal cost curves that are substantially lower than the cost distribution curve obtained when using the entire Raimi et al., data set. In the interest of conservatism, we elect to rely on the full Raimi et al., data set. See also: https://drive.google.com/file/d/19dlfOmzhCvjTxLcdWXOoHdg39x24EOqf/view.

with the highest cost for well plugging and surface reclamation costs observed in the Raimi data set. For shallow wells (extending up to 4,000 feet below the surface) we assume an exponential distribution based on Raimi et al., (2021) data for all wells, but with a maximum cost of $500,000 (which reflects the highest cost for wells with depths up to approximately 4,000 feet.)

We believe that these estimates reasonably characterize the distribution of potential shallow and deep well repair costs in the event well-related release events were to occur at the EWS Hub Project site.

### 7.2 Cost Distribution for USDW Non-Endangerment

- Minimum: $50,000
- Maximum: $1,423,500
- Uniform distribution

We apply the above cost distribution to all incidents that involve a well, caprock or fault release that occurs in a Monte Carlo trial. This distribution reflects several different response components, including the characteristic use of USDWs in the AOR for the EWS Hub Project Site and the professional judgement of experts versed in federal and state response action to groundwater contamination incidents. We describe the underlying basis for this cost distribution below.

For groundwater that is intended for domestic use, Wyoming state groundwater regulations incorporate federal groundwater quality standards established by EPA.[22] The National Primary Drinking Water Regulations (NPDWRs) developed by EPA establish mandatory water quality standards for drinking water contaminants. These standards are referred to as "maximum contaminant levels" (MCLs), which are intended to protect the public against consumption of drinking water contaminants that present a risk to human health. An MCL is the maximum allowable amount of a contaminant in drinking water delivered to the consumer.

National Secondary Drinking Water Regulations (NSDWRs) set non-mandatory water quality standards for 15 contaminants. These standards (referred to as "secondary MCLs or SMCLs") are offered as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor. These contaminants are not considered to present a risk to human health at the SMCL.[23]

Consistent with these mandates, we evaluate potential consequences arising from release incidents or WWQR event-based risk activities at the project site, which could result in an exceedance of one or more MCLs in a USDW. We do so because, however unlikely, it is possible that such incidents could result in the need for an emergency and remedial response action. Our evaluation of potential consequences begins with the composition of the CCUS stream and the potential pathways for harm to USDWs.

- Composition of the CCUS Stream. Tallgrass anticipates that the CO2 injectate will meet the minimum pipeline specifications identified in Exhibit 4; and, the sponsor intends to operate the EWS Hub Project in compliance with WWQR water quality standards.[24] However, for some constituents, the pipeline specification limits in Exhibit 1 do not provide enough information to assess the potential for an MCL exceedance. For example, 'hydrocarbons' may contain various polycyclic aromatic hydrocarbons (PAHs), for which there are established MCLs. Therefore, it is possible that such contaminants could impair groundwater uses designated by the state. To address these uncertainties, as well as the possibility for trace amounts of contaminants other than those identified in Exhibit 1, the cost distributions (discussed in later sections of this document) assume use of reverse osmosis (RO)

[22] See WWQR Chapter 8, Section 4(d)(v)(A).
[23] See https://www.epa.gov/sdwa/secondary-drinking-water-standards-guidance-nuisance-chemicals.
[24] WWQR Chapter 8 cites to Federal regulatory standards (see Chapter 8 Section 4(d)(v)). Further, the Chapter also states that any release to underground water must not impair designated use(s) for particular aquifers.

treatment units for residences potentially affected by a release event. RO treatment units are highly effective at removing a wide variety of contaminants, including PAHs.[25]

- Potential Pathways for Endangerment of USDWs. In addition to 'direct' impacts resulting from a release of constituents present in the CCUS stream into a USDW, 'indirect' impacts could arise if released CO2 reduces the USDW's pH sufficiently to increase the leaching of heavy metals from aquifer minerals at concentrations that exceed an MCL. It also is possible that increases in subsurface pressure arising from injection activities could result in USDW impacts due to resulting movement of underground brines. This analysis incorporates emergency and remedial response actions to address potential MCL exceedances that could arise in these scenarios. We anticipate that these actions also would address any aesthetic impacts (e.g., taste, color, odor, etc.) that could be associated with potential exceedance of secondary MCLs (e.g., for pH, TDS, chlorides, etc.).[26]

Exhibit 1 provides context regarding land use within the EWS Hub Project site AOR. As illustrated in the image, land use in the approximately 210 square mile AOR is highly rural, with a low density of scattered residences and a substantial amount of agriculture and ranching/livestock activity. There are neither municipal water systems, nor population centers within the AOR. Data provided by the project sponsor indicate that there are approximately 841 water wells distributed throughout the AOR (approximately 394 for domestic use, 390 for livestock watering (some dual-purpose domestic/livestock), 267 for irrigation, and three for 'industrial'purposes). The maximum water well depth is 3,511 feet, all others are at depths less than 1,000 feet, approximately 796 wells are depths less than 500 feet. The deepest domestic well is 735 feet.

**Exhibit 4. EWS Hub Project CO2 Pipeline Specifications**

| Constituent | Limit |
|---|---|
| $CO_2$ | >96 mol% |
| CO | < 0.4 mol% |
| $H_2$ | < 0.5 mol% |
| $H_2S$ | < 20 ppm |
| Total Sulfur | <35 ppm |
| Total $NO_x$ | <10 ppm |
| $O_2$ | < 10 ppm (w) |
| $H_2O$ | < 150 ppm |
| Hydrocarbons | <4 mol % |
| Glycol | 0.3 gallons/MMCF |
| Maximum dew point at 400 psig | 30°F |
| Non condensable gases | <3% mol% |

Based on the aforementioned site context, we estimate a maximum per-incident cost range tailored to the EWS Hub Project site as follows:

[25] For example, as noted on EPA's website "RO and NF [nanofiltration] are useful for the removal a wide range of contaminants. RO can remove contaminants including many inorganics, dissolved solids, radionuclides and synthetic organic chemicals. RO can also be used for removing salts from brackish water or sea water." https://www.epa.gov/sdwa/overview-drinking-water-treatment-technologies#RO

[26] Information provided by the project sponsor confirms that there are no USDWs (i.e., <10,000 mg/l total dissolved solids) below the storage zone, and therefore no threat of USDW endangerment from releases that might occur (however unlikely) through the bottom seal. Further, were any releases to occur at the EWS Hub site that could impact mineral rights, human health, ecological health, storage rights or property and infrastructure, such releases would need to penetrate and migrate through the upper confining layer of the storage zone and not through the bottom seal.

- A maximum of $75,000[27] to drill new water monitoring wells, to facilitate data collection to evaluate the spatial extent, existence, and/or significance of a potential release-related plume for existing water users,[28] plus;
- A maximum of $13,000[29] for quarterly sampling and analysis for standard field measurements and heavy metals at an estimated $200 per sample,[30] including collection and analysis, for up to two years and 8 residences,[31] plus;
- A maximum of $3,500[32] for residential replacement water for one year for up to 8 residences,[33] plus;
- A maximum of $20,000[34] for purchase and installation of residential reverse osmosis (RO) units at up to 8 residences,[35] plus;
- A maximum of $12,000[36] for RO replacement filters, including servicing of such units at $300 per unit per year for up to five years at 8 residences,[37] plus;
- A maximum of $400,000 for irrigation support,[38] plus;

[27] $75,000 = 4 wells * 750 foot depth * $25 drilling cost per foot.
[28] At an estimated drilling cost of $25 per foot (see https://homeguide.com/costs/well-drilling-cost#cost, which estimates a cost of $15-$25 per foot for drilling a water well), this cost allowance would allow, for example, drilling of four new wells at a 500-foot depth.
[29] $13,000 (rounded) = 8 residences * 8 quarterly samples * $200 per sample.
[30] See for example information from laboratory vendor Chemtech international at https://chemtech-us.com/articles/cost-of-well-water-testing-in-2021/#:~:text=It%20costs%20%24165%20at%20the,%24279%20at%20the%20full%20price, which states "the Essential Water Test is a standard test that screens the general water chemistry, the hardness and alkalinity of the water, toxic and heavy metals, nitrates and nitrites, coliform and E.coli bacteria, and silica. It costs $165 at the full price." We round up to $200 to account for potential sample collection costs.
[31] If there is a release incident, a common response measure would be to periodically test water wells within the potential impact area to determine if any residences are at risk of exposure to contaminants at levels above an MCL. If no impacts are found within two years of an incident, we anticipate that continued testing would no longer be necessary. Alternatively, if household treatment needs arose, we anticipate that treatment solutions would be implemented within two years of the incident. As a result, testing of residential wells should be unnecessary after two years.
[32] $3,500 (rounded) = 8 residences * $35 per month for 25 gallons * 12 months.
[33] If residential water well testing identifies contaminant levels of concern, replacement water for drinking and cooking would be provided for affected residents. Commercial companies offer water delivery service at approximately $35 per month for 25 gallons, a typical consumption level for a family of 3-4 (see for example pricing and family water quantity recommendations from water vendor Culligan at https://www.culligan.com/bottled-delivery/select). This pricing estimate is conservative, as it is likely that bottled water could be provided in bulk at costs lower than those charged by residential delivery services. We also note that replacement water typically is a temporary measure; in this case, if contamination issues persist for longer than one year, we anticipate that the replacement water program would end and be replaced by installation of residential reverse osmosis units to provide clean water, which is a more expensive, but more appropriate solution for longer term contamination issues.
[34] $20,000 = 8 residences * $2,500 per RO unit.
[35] While some residential RO units (and other types of residential treatment technologies) can cost several hundreds of dollars, for this analysis, we assume installation of the much more expensive Kinetico K5 Drinking Water Station RO unit, which is an RO model currently designated for use in response to a severe, long-term groundwater contamination incident in North Carolina, affecting thousands of residences (see https://edocs.deq.nc.gov/WasteManagement/DocView.aspx?id=1636579&dbid=0&repo=WasteManagement). Pricing information from Consumer Reports indicates that $2,500 is a reasonable cost estimate for this unit.
[36] $12,000 = 8 residences * $300 per RO unit per year * 5 years.
[37] Annual RO unit maintenance costs will vary depending on water use, contaminant levels and other factors. Based on warranty information, replacement filter prices and professional judgement, $300 per year per unit is a reasonable approximation of annual maintenance costs. For reasons described throughout this document, we anticipate that release incidents that occur should be resolvable within months or a few years. Out of an abundance of caution, for purposes of cost estimation, we assume maintenance of RO units for five years after installation to allow for natural dilution/dissipation of any residual CO2/low pH/brine plume, supplemented by active remediation, if needed.
[38] Information provided by the project sponsor indicates that there are approximately 267 irrigation wells within the approximately 210 square mile AOR. While difficult to forecast specific irrigation needs in response to a potential release event due to seasonal timing, weather, specific crop requirements, and other factors, $400,000 provides a significant incident-specific sum that could be used for a variety of potential response activities, including but not limited to: funding new irrigation system connections to existing, unaffected wells; digging new wells in areas away from potential release impacts and connecting them to irrigation systems; farm-specific treatment solutions; and temporary replacement water (trucked water can cost about $30-$65 per 1,000 gallons).

- A maximum of $400,000 for ranch/livestock support,[39] plus:
- A maximum of $500,000 for additional response and remedial actions.[40]

Summing the maximum dollar amount for each of these components results in a total maximum per-release cost of $1,423,500, in 2023 dollars.

The maximum per-release cost reflects a cost distribution for USDW non-endangerment that is tailored to the site specific circumstances of the EWS Hub Project site. We rely on a minimum cost of $50,000 for the cost distribution, reflecting the potential for small releases insufficient to cause measurable adverse impacts, or for releases that cause minor impacts, which are easily addressed at minimal cost. For estimation purposes, we assume a uniform probability distribution in the Monte Carlo trials. That is, every incident that occurs in a trial is randomly assigned a cost from the cost distribution discussed above; and every cost within that range has an equal chance of being assigned. We offer additional context for our approach below.

Evaluation of the EWS Hub Project site suggests that the most likely pathway for a potential release that could impact a USDW in the project's AOR is migration through a well of some kind. Such releases are associated with a very specific release location; and, tend to offer a better opportunity to identify and mitigate impacts than often is available at groundwater contamination sites caused by spatially dispersed, slow infiltration of contaminants from the surface.

As previously noted, the composition of the EWS Hub Project site's CCUS stream has a very low potential for introducing co-constituents that could directly contaminate a USDW and cause an exceedance of a health-based MCL. Rather, potential impacts from a release more likely would occur indirectly by: 1) lowering groundwater pH, which, in turn, could lead to increased dissolution of metals present in the aquifer matrix (if present in sufficient quantities); or 2) injection-related increases in subsurface pressure that results in the vertical migration of underground brines into a USDW.

Importantly, there are natural factors that are likely to limit the impact of any released $CO_2$ on pH at the EWS Hub Project site. Specifically, carbonate will act to buffer pH from changes due to $CO_2$ – with a carbonate concentration of even 1% by weight, pH changes are unlikely to be meaningful. Although carbonate aquifer matrix measurements in or near the AOR were not available, information provided by the project sponsor

[39] Information provided by the project sponsor indicates that there are approximately 390 water wells within the approximately 210 square mile AOR identified as serving 'stock watering' purposes (although many also co-list 'domestic' water provision). $400,000 is a substantial sum that could, for example, allow for drilling one or more new wells in areas away from potential release impacts and connecting them to existing water delivery systems; facilitating more complex treatment solutions; enabling dilution with other unimpacted water sources; or providing temporary bulk replacement water (trucked water typically can cost about $30-$65 per 1,000 gallons). While water needs for livestock will depend on the season, type and age and other livestock characteristics, as an approximation we note that beef cattle can require 4-20 gallons of water per day, per head (see https://www.ag.ndsu.edu/publications/livestock/livestock-water-requirements). As additional context, if livestock required 10 gallons per day per head, and replacement water could be obtained for $65 per 1,000 gallons, that implies an annual replacement water cost on the order of roughly $250 per head per year.

[40] As part of the emergency and remedial response to a release incident involving a WWQR event-based risk activity, additional actions might be needed to protect USDWs, including limiting plume movement, accelerating dilution of CO2 concentrations or brine, extracting CO2 or brine-related contamination through air stripping or other technologies, buffering pH or constructing reactive barriers to limit CO2 impacts, reducing subsurface pressure by halting CO2 and/or other subsurface injection activities in relevant areas, and/or otherwise undertaking actions to speed the return of an impacted USDW to baseline conditions. This cost estimate reflects several factors: as discussed elsewhere in this document, CO2 releases or pressure-related brine movement through faulty wells is the most likely release pathway and can be relatively straightforward to stop through well repair/plugging; the aquifer matrix is likely to have meaningful buffering capacity that limit pH changes; resultant/residual plumes of groundwater with substantially reduced pH are not likely to be large or long-lived; dilution/natural attenuation can reduce CO2 and/or brine levels without intervention; CO2 is relatively inexpensive to remove from groundwater; low pH also is relatively inexpensive to address; subsurface pressure fronts can dissipate relatively quickly after the cessation of injection activities if lateral plume movement in the injection zone is not confined; "thief" zones between the injection formation and USDW can absorb CO2 or brine flux; density differences due to temperature and salinity can limit the vertical migration of displaced brine; and rural land use patterns and the low density of water wells in the AOI limit the potential for plume impacts on water users.

indicates that the primary injection zone is in the Lyons formation, which in some locations includes carbonates. There is one groundwater alkalinity[41] measurement in the vicinity of the AOR and it exceeds 200 mg/L, which suggests some potential for buffering capacity.

For USDW endangerment to occur from a CO2 release event that lowers aquifer pH, there also needs to be a sufficient reservoir of metals in the aquifer matrix to be leached into USDWs to result in health-based MCL exceedances. According to the project sponsor, concentrations of metals in the aquifer matrix in the AOI are not known.

With respect to potential pressure-induced brine migration into a USDW, halting or modifying injection activity until corrective action is taken (e.g., plugging/repairing a deep well that allowed brine to migrate to a USDW) can reduce subsurface pressure and limit the spatial extent/duration of potential impact. After injection is complete at the site the pressure front will dissipate over time, which also can limit the potential for USDW endangerment during the PISC period. Articles from the peer-reviewed technical literature identify additional factors that can limit potential impacts from brine migration. For example, Nicot et al., (2009) note that "owing simply to density differences due to temperature and salinity subsurface variations, a wellbore with a continuous open pathway between the injection formation and the bottom of the USDW will not necessarily lead to [brine] contamination of the USDW when CO2 is injected."[42] Nicot et al., also note that Minkoff et al., (2007) and Chang et al., (2008) showed that "thief" zone(s) between the USDW and injection formation "can attenuate significantly well bore pressure and absorb a significant fraction of the material flux."[43]

These factors support the reasonable assumption that, if a plume occurred in a USDW as a result of a release incident, that plume likely would be relatively modest in size. For example, analyses in relevant published literature generally describe radial $CO_2$ plume distances on the order of hundreds of meters or less.[44] Nevertheless, to estimate potential residential and irrigation impacts from a release incident associated with the EWS Hub Project Site, we conservatively assume that an impact plume could extend up to one mile from the release point and potentially endanger the aquifers currently used by local residents.

Specifically, an impact plume with a radius on the order of one mile from its center would affect an area roughly 3.14 square miles in size.[45] With respect to the potential number of residences that might be affected if a release event of that size were to occur in the EWS Hub Project site's AOR, our evaluation assumes impacts to a maximum of 8 households. As previously noted, satellite imagery (see Exhibit 1) shows that most of the AOR is highly rural, with a low density of scattered residences and a substantial amount of agriculture and ranching/livestock activity. As previously noted the AOR is approximately 210 square miles in size and includes approximately 394 domestic water wells, which implies an average density of about 1.9 domestic wells per square mile or about 6.0 domestic wells within a hypothetical release incident impact radius of 3.14

[41] Alkalinity is a different measure of the capacity of water (or any solution) to neutralize or "buffer" acids.
[42] See Nicot, Jean-Philippe, Curtis M. Oldenburg, Steven L. Bryant and Susan D. Hovorka "Pressure perturbations from geologic carbon sequestration: Area of-review boundaries and borehole leakage driving forces" in Energy Procedia 1 (2009) 47-54.
[43] As cited in Nicot et al., (2009): S. E Minkoff,. S. L. Bryant, J.-P. Nicot, and C. M. Oldenburg, Modeling leakage of CO2 along a fault for risk assessment (abs.), in Sixth Annual Conference on Carbon Capture & Sequestration: Expediting deployment of industrial scale systems: Can it be done? How? Concerns to be addressed, May 7–10, Pittsburgh, Abstract #053, (2007) and K.W Chang, S. E. Minkoff and S. L. Bryant, Modeling Leakage through Faults of CO2 Stored in an Aquifer, SPE 115929, presented at 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.
[44] See for example Elizabeth Keating, D. Bacon, S. Carroll, K. Mansoor, Y. Sun, L Zheng, D. Harp and Z. Dai. Applicability of aquifer impact models to support decisions at CO2 sequestration sites. International Journal of Greenhouse Gas Control 52 (2016) 319-330. and Nicholas Huerta, D. Bacon, C. Carman and C. Brown. NRAP Toolkit Screening for CarbonSAFE Illinois – Macon County. Illinois State Geological Survey Prairie Research Institute and Pacific Northwest National Laboratory. Report prepared for US DOE 00029381. 2020.
[45] 3.14 square miles = $\pi$ * (1 mile radius)$^2$ = 3.14 * 1 square mile.

square miles.[46] Overall, publicly available information suggests an average residential density within the AOR that is well below the 8 residences per 3.14 square miles conservatively used in this analysis.

### 7.3 Cost Distribution for Endangerment to Human Health from Acute or Chronic Surface Release of CO2 Injectate

- Minimum: $0
- Median: $100,000
- 75th Percentile: 200,000
- Maximum: $900,000
- Bimodal distribution

We apply the above cost distribution to all incidents that involve a well, caprock, fault or pipeline release that occurs in a Monte Carlo trial.

There is a non-zero possibility that WWQR event-based risk activities may result in release incidents. Such incidents can create acute or chronic exposures to nearby residents necessitating emergency and remedial response. The maximum end of the cost distribution is based on the CO2 pipeline incident that occurred in Satartia, Mississippi in 2020.[47] It is generally accepted that this incident resulted in the most significant CO2-related public health impact to date.[48]

The Satartia MS incident resulted in 45 hospitalizations. National Institute of Health (NIH) data suggests a 12-month treatment cost for 'unintentional suffocation or poisoning' at approximately $10,000 per person.[49] We believe that this estimate is reasonably conservative, and set it as the upper-bound (maximum) of the cost distribution. Importantly, the Satartia MS impacts occurred, in part, because a CO2 pipeline was located close to a small town. To our knowledge, there are no comparable towns or population centers in the AOR associated with the EWS Hub Project site.

In addition to treatment costs, we assume an additional $10,000 per person to address potential lost income and/or pain and suffering associated with a release incident that adversely impacts human health. Median per capita income for Wyoming residents is approximately $40,000.[50] We conservatively assume an average of one month's lost income for individuals affected by a pipeline release (i.e., slightly more than $3,000 per person). We assign approximately $7,000 per-person (to arrive at the $10,000 included in the cost distribution)

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[46] 7.5 wells (rounded) = (48 water wells / 20 square mile AOI) * 3.14 square mile hypothetical contamination impact area with a radius of 1 mile from its center.

[47] US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Pipeline Safety Accident Investigation Division. Failure Investigation Report – Denbury Golf Coast Pipelines, LLC – Pipeline Rupture/Natural Force Damage. May 26, 2022. On February 22, 2020, Denbury's 24-inch Delhi Pipeline ruptured, releasing liquid CO2 that immediately began to vaporize at atmospheric conditions. The site of the rupture was approximately one mile southeast of Satartia, Mississippi. Denbury reported that the rupture released an estimated total of 31,405 barrels of CO2. Local authorities evacuated approximately 200 people near the rupture, including the entire town of Satartia (around 50 residents), and three homes across the Yazoo River. Forty-five people sought medical attention at local hospitals, including individuals who were caught in the vapor cloud while driving a vehicle. One individual was admitted to the hospital for reasons unrelated to the pipeline failure. There were no fatalities.

[48] To our knowledge, there are no documented 'real world' CO2 release events arising from land-based injection wells that resulted in documented human health impacts. In the absence of such data, we conservatively rely on a pipeline incident as a proxy for the types of surficial CO2 release events relevant to the CCS context. We do so because the types of impacts that might arise from a pipeline rupture are not dissimilar to those that might arise from an acute or chronic surface release of CO2 injectate from a CCS operation. We believe this approach to be both reasonable and conservative. To date, the most significant 'real world' CO2-related impact event in the United States that resulted in acute / chronic CO2-related impacts is the February 2020 Satartia, MS pipeline release. In our view, in the absence of other data specific to Wyoming, this release event offers a conservative proxy for estimating a cost distribution for endangerment to human health arising from an acute or chronic surface release of CO2 injectate.

[49] Peterson, Cora, Likang Xu and Curtis Florence. Average medical cost of fatal and non-fatal injuries by type in the USA. Inj Prev. 2021 February ; 27(1): 24–33. doi:10.1136/injuryprev-2019-043544. To our knowledge, there are no documented, publicly available and comparable Wyoming-specific treatment cost information. In the absence of such data, we rely on national cost estimate data as a reasonably proxy.

[50] https://www.census.gov/quickfacts/WY.

to address potential pain and suffering.[51] Given the likelihood that the potential impacts associated with CO2-related morbidity are likely to be relatively short-term, we believe $7,000 (about twice estimated lost income, and comparable to treatment costs) is reasonably conservative for purposes of deriving a financial assurance cost estimate.

Based on the information described above, we use a maximum cost estimate of $900,000.[52] We also include a minimum value of $0 in the cost distribution, because acute and chronic surface releases of CO2 injectate may have no human health impact. For example, in many circumstances, atmospheric dilution quickly reduces CO2 concentrations below relevant human health thresholds; there is diminished likelihood that, in this rural AOR with no population centers, people will be close enough to surface release locations to receive meaningful exposure; the injectate composition contributes to reduced risk (e.g., no hydrogen sulfide); and implementation of the emergency response plan will help avoid impacts.

Readily available data indicate that public health impacts due to the transport and industrial use of CO2 are rare. A recent evaluation of PHMSA data identified 113 CO2 pipeline incidents that occurred between 1994 and 2021; to our knowledge, the Satartia, MS release is the only one that resulted in public health impacts.[53] Importantly, we have been unable to find documentation of any public health impacts arising from CO2 used in enhanced oil recovery operations or other industrial activities.

In light of this research we use a bimodal cost distribution to conservatively assume that 10% of subsurface or pipeline release events result in some level of human health impact. As a result, 90% of subsurface or pipeline release events are assigned $0 cost, because there no human health impacts expected to occur. For the remaining 10% of events, we assume a minimum cost of $20,000 (consistent with harm to one person) and a maximum cost of $900,000 (consistent with the Satartia, MS pipeline incident).

Further, we assume a median cost of $100,000 and a 75$^{th}$ percentile cost of $200,000, approximately consistent with impacts to five to ten people, respectively. In our view, this cost distribution reasonably reflects the potentially exposed population, if an incident were to occur near a residence or small gathering in this highly rural area. Finally, we apply a Burr distribution to the cost range – while higher cost incidents potentially could occur, the AOR characteristics of the EWS Hub Project suggest that impacts to small numbers of people are substantially more likely than impacts to larger numbers of people.

### 7.4 Cost Distribution for Ecological and Response/Infrastructure Costs from Acute or Chronic Surface Release of CO2 Injectate

- Minimum: $5,000
- Maximum: $450,000
- Burr distribution

We apply the above cost distribution to all incidents that involve a well, caprock, fault or pipeline release incident that occur in a Monte Carlo trial.

This distribution is based on release-related cost information reported to the U.S. Department of Energy Pipeline and Hazardous Materials Safety Administration (PHMSA) for the 103 CO2 pipeline release incidents recorded from 2002 through 2021. We believe that PHMSA offers the most reasonably conservative data for estimating costs associated with ecological response, and property and infrastructure damage, including changes to surface topography and structures, arising from acute or chronic surface releases of CO2 injectate.

[51] Pain and suffering amounts (if awarded) are difficult to forecast and depend largely on legal jurisdiction, case-specific circumstances, and other factors impossible to predict with any degree of certainty.
[52] $900,000 = 45 people impacted * ($10,000 per person treatment cost + $10,000 per person lost income/pain & suffering)
[53] Vitali, Matteo, C. Zuliani, F Corvaro, B Marchetti and F Tallone. Statistical Analysis of Incidents on Onshore CO2 Pipelines Based on PHMSA Database. Journal of Loss Prevention in the Process Industries 77 (2022) 104799.

Specifically, the Monte Carlo simulation includes PHMSA-identified costs arising from emergency response, environmental remediation and non-operator property damage due to release incidents. We do not include private-party costs, including, for example, the value of product lost or operator property damage, as these categories do not inform emergency and remedial response actions responsive to estimating financial assurance cost estimates for WWQR event-based risk activities.

Although PHMSA data indicate that most incidents resulted in relevant costs *less than* $5,000 per incident, we conservatively assign $5,000 as the cost distribution minimum. This cost estimate is intended to reflect minor incidents with minimal response-related activities.

We use $450,000 as the cost distribution maximum, which reflects the single incident with the highest cost in the PHMSA data (adjusted for inflation); that is, the 2020 Sartartia, MS pipeline release. The total cost for this WWQR event-based risk activity is $431,361, which results from the afore-mentioned cost categories. We apply a Burr distribution to reflect the fact that pipeline release costs are skewed towards the lower end of the distribution – although higher costs can occur, they do so much less frequently than lower costs.

### 7.5 Cost Distribution for Mineral Rights Infringement

- Minimum: $0
- Maximum: $35,000
- Bimodal distribution

We apply the above cost distribution to all incidents involving well, caprock or fault releases that occur in a Monte Carlo trial.

Data on Wyoming mineral rights are available from the state's Office of State Lands and Investments. We downloaded geospatial layers for active oil and gas and mineral rights and cross-referenced them with the AOR shapefile for the EWS Hub Project. This cross-reference revealed 17 active oil and gas leases in the AOR issued between December 2018 and August 2023; and, a total of 7,478 acres with no active mineral leases. The active oil and gas leases cover approximately six percent of the roughly 210 square mile AOR.

Few of the 'active' oil and gas leases in the AOR appear to be producing oil or gas. Information provided by the project sponsor indicates that there are approximately 84 oil and gas wells in the AOR, but only two wells are identified as active, and the vast majority (at least 75) of these oil and gas wells are identified as plugged and abandoned.

Further, we note that only three of the 84 wells are deep enough to extend into the planned CO2 storage interval. In our view, it is reasonable to expect that most mineral activity would continue at depths shallower than the subsurface confining layers above the CO2 storage plume. Conceptually, however, it is possible that a subsurface release event could temporarily interfere with mineral extraction operations that were planned or underway in subsurface areas adjacent to the release.

To reflect these site-specific circumstances, we use a bimodal cost distribution. If a subsurface release event occurs in a Monte Carlo trial, we assign a 94% chance of $0 cost, reflecting an event that occurs somewhere in the 94% of the AOR without an active mineral lease. We also assign a 6% chance of a cost between $5,000 and $35,000 (the total cost of all currently actively leases in the AOR). This cost distribution reflects the possibility that the project sponsor may need to "refund" the equivalent of a lease payment to affected mineral rights holders in response to potentially interfering with the holder's ability to exercise their lease rights.[54]

[54] Losses and attendant cost estimates for environmental and/or ecological event-based risks are addressed in other sections of this report. Other types of losses from a WWQR risk-based event activity involving mineral rights infringement (e.g. lost profits, business interruption) are not quantifiable at this time, given that there is limited active mineral operation activity in the AOR. Quantifying any such potential losses are too speculative to result in a reasonable or meaningful cost estimate. Per the regulations, the financial

It is our understanding that Wyoming mineral leases typically reflect a five-year term, require a lease payment, and a royalty based on mineral production. The Wyoming Office of State Lands and Investments data indicate that active lease payments in the AOR for current leases (i.e., issued between December 2018 and August 2023) total $32,138 (which we conservatively round to $35,000 for purposes of this analysis).

Royalty payments data are not readily available, but likely are negligible given the small volume of actual production in the AOR. For this portion of the bimodal distribution, we assume all costs between $5,000 and $35,000 to be equally likely (i.e., a uniform distribution).

Finally, it is possible that active mineral operations could experience other types of losses from a WWQR risk-based event activity (e.g. lost profits, business interruption). At this time, given that there is such limited active mineral operation activity in the AOR, quantifying any such potential losses would be too speculative to result in a reasonable cost estimate.

Per WWQR Chapter 24, Section 26(b), financial assurance cost estimates (including those that address emergency and remedial response associated with WWQR risk-based event activities like mineral rights infringement) must be updated annually, or within 60 days of receiving notice that the Administrator has determined that a demonstration of financial assurance is no longer adequate. Consistent with Section 25(a)(i) and (a)(ii) requirements, financial assurance cost estimates also will need to be reevaluated after any updates to the emergency and remedial response plan. Consistent with these regulatory requirements, to the extent actual mineral extraction activity in the AOR increases during the life of the EWS Hub Project, the financial assurance cost estimates will be reevaluated.

### 7.6 Cost Distribution for Property and Infrastructure Damage Arising from Induced Seismicity

- Minimum: $0
- Median: $275,000
- 75$^{th}$ Percentile: $1,000,000
- Maximum: $2,750,000
- Burr distribution

We apply the above cost distribution to all induced seismic events that occur in a Monte Carlo trial.

To develop this cost distribution, we develop a dataset of all parcels that intersect with the AOR by combining: 1) Wyoming Department of Revenue statewide property assessment and valuation data; 2) the shapefile of the EWS Hub Project AOR; and 3) a separately-accessed shapefile of all parcels in Laramie County. This data analysis yielded 905 individual parcels, as of tax year 2023.

The property value data for these parcels are summarized in Exhibit 5, including the value of land and any improvements made to the land (generally, structures). Exhibit 6 summarizes the same data set, but excludes land values.

In our view, an induced seismic event of the magnitude relevant to the EWS Hub Project (discussed further below) could adversely impact structures, but is not likely to result in adverse impact to the land, itself. We estimate there is approximately $110 million property infrastructure within the AOR that potentially could be adversely impacted by an induced seismic event.

As previously indicated, the project sponsor's seismicity evaluation found a 2% probability of exceedance in 50 years for seismic events ranging from 5% to almost 14% peak ground acceleration (in southeastern and northwestern Laramie County, respectively). For purposes of deriving a financial assurance cost estimate for

assurance cost estimates will be reevaluated annually, at which time estimates of losses (if any) will be refined to reflect actual increases in mineral extraction activity in the AOR.

emergency and remedial response related to this WWQR risk-based event activity, we converted peak ground acceleration numbers into a measure of possible monetary damage.

Exhibit 7 summarizes information from the United States Geological Survey (USGS) that relates peak ground acceleration to Modified Mercalli Intensity (MMI), a commonly referenced measure of earthquake intensity. The maximum peak ground acceleration of 14% estimated for the AOR corresponds to MMI category VI (which includes seismic events with peak ground accelerations between 9.2% and 18%).

The USGS also provides summary information describing the type of damage associated with different MMI categories (see Exhibit 8). As show in Exhibit 8, MMI Category VI events are associated with events "felt be all, many frightened, some heavy furniture moved, a few instances of fallen plaster. Damage slight." Relying on these representations, we assume a maximum repair cost equal to 2.5% of total structure value.

### Exhibit 5. Summary of Property Values for Parcels in the AOR

| Parcel Type | Count | Total Acreage | Average Acreage | Total Value ($) |
|---|---|---|---|---|
| Agricultural | 463 | 131,746 | 285 | $127,109,758 |
| Commercial | 13 | 39 | 3 | $970,372 |
| Commercial – Vacant Land | 4 | 61 | 15 | $84,813 |
| Industrial | 5 | 206 | 41 | $1,856,290 |
| Industrial – Vacant Land | 8 | 315 | 39 | $315,149 |
| Residential | 255 | 6,241 | 24 | $59,719,027 |
| Residential – Vacant Land | 117 | 5,344 | 46 | $6,043,123 |
| Exempt, w/ data | 13 | 660 | 51 | $374,191 |
| *Exempt, w/o data* | *24* | *7,331* | *305* | -- |
| *N/A (no data available)* | *3* | -- | -- | -- |
| **Total Parcels with Data** | **878** | **144,612** | **165** | **$196,472,723** |

Notes: From Laramie County, Wyoming geospatial data (https://maps.laramiecounty.com/arcgis/rest/services/features/CountyBaseMapFeatures/MapServer/2). Fields relied upon: "accttype" for parcel type; "netacres" for acreage; and "totalcostv" for value.

### Exhibit 6. Summary of Parcel Structure Values in the AOR

| Parcel Type | Count | No. w/ Improvements | Total Impr. Value |
|---|---|---|---|
| Agricultural | 463 | 177 | $56,815,755 |
| Commercial | 13 | 13 | $801,435 |
| Commercial – Vacant Land | 4 | 0 | -- |
| Industrial | 5 | 5 | $1,398,907 |
| Industrial – Vacant Land | 8 | 0 | -- |
| Residential | 255 | 249 | $50,660,131 |
| Residential – Vacant Land | 117 | 0 | -- |
| Exempt, w/ data | 13 | 0 | -- |
| *Exempt, w/o data* | *24* | *0* | -- |
| *N/A (no data available)* | *3* | *0* | -- |
| **Total Parcels with Data** | **878** | **444** | **$109,676,228** |

Notes: From Laramie County, Wyoming geospatial data (https://maps.laramiecounty.com/arcgis/rest/services/features/CountyBaseMapFeatures/MapServer/2). Fields relied upon: "accttype" for parcel type; "netacres" for acreage; "totalimpsv" for improvement value; and "totalcostv" for total (land plus improvement) value.

We believe this estimate is reasonably conservative and likely would be sufficient to address potential damage on the order of "a few instances of fallen plaster." To derive the maximum value for this cost distribution, we assume all structures in the AOR are impacted by a seismic event and require the maximum level of repair (i.e., 2.5% of total structure value). This assumption results in a cost distribution maximum of $2.75 million.[55] We use a minimum cost distribution value of $0, because induced seismic events can occur at low intensities with no attendant damage. We also assume a median distribution value of $275,000, consistent with an event that impacts approximately 10% of the 210 square mile AOR. Experience in areas with relatively high incidences of induced seismicity (e.g., Oklahoma) suggest that the spatial extent of impact is substantially more likely to be on the order of 20 square miles than 200 square miles.[56] For similar reasons, we assume a 75$^{th}$ percentile estimate of $1,000,000 and use a Burr distribution for this cost range.

### Exhibit 7. Modified Mercalli Intensity Relative to Peak Ground Acceleration, Perceived Shaking and Potential Damage*

| Modified Mercalli Intensity | Acceleration (%g) (PGA) | Perceived Shaking | Potential Damage |
|---|---|---|---|
| I | <0.17 | Not felt | None |
| II | 0.17 – 1.4 | Weak | None |
| III | 0.17 – 1.4 | Weak | None |
| IV | 1.4 – 3.9 | Light | None |
| V | 3.9 – 9.2 | Moderate | Very Light |
| VI | 9.2 – 18 | Strong | Light |
| VII | 18 – 34 | Very Strong | Moderate |
| VIII | 34 – 65 | Severe | Moderate to Heavy |
| IX | 65 – 124 | Violent | Heavy |
| X | >124 | Extreme | Very Heavy |
| XI | >124 | Extreme | Very Heavy |
| XII | >124 | Extreme | Very Heavy |

*See, for example, https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/atoms/files/EQ101.pdf.

### Exhibit 8. Damage Potential Associated with Different MMI Category Events*

[55] $2.75 million = $110 million total value of structures in the AOR * 2.5% maximum repair cost.

[56] See, for example, Celebi, Mehmet et al. EERI Earthquake Reconnaisance Team Report: M5.0 Cushing Oklahoma USA Earthquake on November 7, 2016. Technical Report February 2017 and Halkia, Georgia and L.G. Ludwig. Household Earthquake Preparedness in Oklahoma: A Mixed Methods Study of Selected Municipalities. International Journal of Disaster Risk Reduction 73 (2022) 102872.

| Intensity | Shaking | Description/Damage |
|---|---|---|
| I | Not felt | Not felt except by a very few under especially favorable conditions. |
| II | Weak | Felt only by a few persons at rest,especially on upper floors of buildings. |
| III | Weak | Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated. |
| IV | Light | Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. |
| V | Moderate | Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop. |
| VI | Strong | Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. |
| VII | Very strong | Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. |
| VIII | Severe | Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. |
| IX | Violent | Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. |
| X | Extreme | Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. |

*See, for example, https://www.usgs.gov/programs/earthquake-hazards/modified-mercalli-intensity-scale

Although analyses completed by the project sponsor suggest a potential peak ground acceleration of 14% for northwest Laramie County, the AOR is in the southeastern portion of the county; and, in fact, the AOR is associated with a lower peak ground acceleration of 5%. This intensity level is associated with MMI Category V, which, in turn, is associated with lower levels of damage ("felt by nearly everyone, many awakened, some dishes, windows broken, unstable objects overturned, pendulum clocks may stop").

Although higher costs (i.e., MMI category VI risk-based event across the entire AOR) could result, we believe they are substantially less likely to occur than lower cost events. Further, as previously noted, the project AOR has limited oil and gas development and lacks the extensive history of deep injection of fluids from nearby oil and gas operations that typically accompany areas experiencing significant induced seismicity.

### 7.7 Cost Distribution for Pore Space Trespass

- Minimum: $5,000
- Maximum: $2,000,000
- Uniform distribution

We apply this cost distribution above to all pore space trespass incidents that occur in a Monte Carlo trial.

As we understand, prior to initial CO2 injection, the project sponsor will have secured all necessary pore space, consistent with processes identified in the State of Wyoming regulations for unitization of geologic sequestration sites (WY § Stat 35-11-315 (2022)). Information provided by the project sponsor indicates that after initial CO2 injection, rights holders will share a lease payment expected to be approximately $1 per ton of CO2, divided among rights holders in proportion to their ownership (i.e., an owner contributing 1% of the area used for storage will receive 1% of the per-ton storage payments).[57]

Presently, the project sponsor forecasts storage of approximately 125.4 million tons of CO2 at the EWS Hub Project site, resulting in total nominal per-ton payments for pore space storage rights of $125.4 million.[58] For

[57] Some rights holders also will receive pre-injection payments, but such payments are not relevant to trespass cost estimation (which can only occur after injection begins).
[58] This total value is consistent with the project sponsor's representation of $1 per-ton of CO2 stored, divided among rights holders in proportion to ownership.

purposes of deriving a financial assurance cost estimate, we assume that the per-ton payments will be made annually over the 30-year injection period, based on injected volumes evinced in the prior year.[59]

Per WWQR Chapter 24: Section 26(b)(i), financial assurance cost estimates must be in current dollars. We determine the present (current) value of the stream of nominal ($1 per ton) pore space payments, based on the operational life of each of the five injection wells that comprise the EWS Hub Project. We do so, using the present value method.[60] The calculations underpinning the present values summarized in Exhibit 9 are based on: 1) anticipated injection rates, as provided by the project sponsor; 2) the staggered schedule for when each of the five injection wells in the EWS Hub Project AOR are anticipated to begin injection, 3) the length of time each individual well is anticipated to remain operational; and 4) annual discount rates aligned to future expected inflation rates[61] published by the Board of Governors of the U.S. Federal Reserve System as a measure of the rate at which prices are likely to change over the life of each injection well. As shown in Exhibit 9, factoring for the above assumptions, pore space rights payments total approximately $90 million (2023$).

**Exhibit 9. Pore Space Rights Payments Discounting Calculations**

| Well | Injection Start Date | Injection End Date | Total Injection Days | Total MMT | Present Value (2023$) |
|---|---|---|---|---|---|
| Cypress | 1/1/2025 | 12/26/2048 | 8,760 | 29,000,000 | $21,298,431 |
| Azalea | 1/1/2025 | 1/1/2055 | 10,957 | 45,000,000 | $31,030,091 |
| Juniper | 1/1/2025 | 1/1/2045 | 7,305 | 11,400,000 | $8,753,331 |
| Barberry | 1/1/2025 | 1/1/2055 | 10,957 | 38,000,000 | $26,203,188 |
| Old Barb | 1/1/2025 | 5/4/2026 | 488 | 2,000,000 | $1,887,901 |
| | | | **Total (5 Wells)** | **125,400,000** | **$89,172,942** |

Importantly, if pore space trespass were to occur, it is possible that no additional payments would be required. As we understand from the project sponsor, the payment amount initially negotiated with pore space rights holders and identified in a unitization agreement (anticipated to be $1 per ton) would remain unchanged, the total payment simply would be divided among a (larger) number of storage acres.

For purposes of financial assurance cost estimation, however, we conservatively assume that is not the case. Rather, we assume that an additional, supplemental payment would be required to pore space rights holders who were not part of the original unitization agreement, and who, subsequent to CO2 injection, experience trespass.

From a timing perspective, trespass is highly unlikely to occur during the early years of injection – in our view, trespass risk increases as the total volume of injection increases and more time is provided for the CO2 plume to move through the subsurface environment. For these reasons, and for purpose of financial assurance cost estimation, we make the reasonable, simplifying assumption that should any trespass occur it is likely to occur during the last 10 years of the project's 30 year injection period. At that time, should trespass occur, 'trespassed' pore space rights holders would be entitled to receive a per-acre payment comparable to that

[59] The project sponsor has represented that such payments may be done quarterly instead of annually. The difference in the time value of money between quarterly and annually is de minimis.

[60] The present value method is used in corporate finance to determine today's value of a stream of future cash flows or payments. Present value analysis is based on the expectation that funds invested, today, can grow over time to match the expected need and timing for funds in the future. This concept is referred to as the Time Value of Money; that is, money available today is worth more than the same amount in the future, because of its potential to earn a return on investment.

[61] See Federal Reserve Bank of Cleveland, "Inflation Expectations" data series: "Expected Inflation and Real and Inflation Risk Premia" at https://www.clevelandfed.org/our-research/indicators-and-data/inflation-expectations.aspx (Nov. 2023).

received by pore space rights holders who were subject to the initial unitization agreement and who received payments during the operational life of the well.[62]

Based on injection volume and the timing information provided by the project sponsor for each of the five injection wells in the AOR, pore space rights payments during the last 10 years of the project's injection period are expected to total approximately $17.5 million (2023$). We assume these payments would be allocated over an average area of 85,000 acres, which implies a total pore space rights payment price of approximately $200/acre over the ten year 'trespass' period.[63] If, instead, the storage plume extended (and thereby trespassed) into an additional 9,500 acres (about 10% of the maximum anticipated plume size), that would result in a total maximum trespass payment of approximately $2,000,000.[64]

Based on the information and approach described above, we use $2,000,000 as the maximum for our potential trespass cost distribution. This estimate is conservative – as previously noted, the actual movement of CO2 in the subsurface environment will be calibrated with modeled predictions on a regular and systematic basis, and therefore it is likely that any potential trespass issue would be identified prior to occurrence and the amount and/or location of ongoing CO2 injection potentially adjusted to reduce or eliminate the trespass concern. In addition, if trespass occurs it is possible that no additional payments would be required (i.e., the storage rights per-injected-ton payment amount would remain unchanged, but divided among a (larger) number of storage acres). To the extent potential trespass begins later than assumed in our calculations, the present value (2023$) of storage rights payments would decrease.

Finally, for purposes of Monte Carlo analysis, we assume a minimum trespass payment of $5,000, which allows for the reasonable possibility of trespass across very small acreages. We apply a uniform distribution to the cost range, which results in an equal chance for selection of every cost within the range.

## 8.0 MONTE CARLO ANALYSIS RESULTS

Based on a model run of 50,000 Monte Carlo trials **we estimate an upper-bound financial assurance cost estimate to satisfy emergency and remedial response and WWQR event-based risk activities of $9.4 million in current 2023 dollars.** This upper-bound cost estimate reflects the single Monte Carlo trial with the greatest financial assurance costs out of the 50,000 trials run (see Exhibit 10). We believe this estimate to be reasonable and appropriately conservative.

[62] We focus on the injection period for these calculations, because pore space rights payments are expected to be made as CO2 is injected. Based on information provided by the project sponsor, no additional storage rights payments are expected during site closure or post-injection site care (PISC).

[63] $200 ($2023) per acre (rounded) = $17.5 million ($2023) pore space rights payments over last ten years of injection / 85,000 acres. The 85,000 acre estimate assumes that during the last ten years of injection, the storage plume size would range between 75,000 acres and its maximum anticipated extent of approximately 95,000 acres.

[64] $2,000,000 (rounded) = $200 per acre * 9,500 acres trespassed

### Exhibit 10. ERR and Event-Based Risk Activity Financial Assurance Cost Estimation Results (2023$)

| Summary Statistic | Cost | # of Events Occurring |
|---|---|---|
| Average | $1,125,916 | 2.37 |
| Standard Deviation | $1,096,628 | 1.53 |
| 5th Percentile | $0 | 0 |
| 50th Percentile | $935,290 | 2 |
| 95th Percentile | $3,228,341 | 5 |
| 99th Percentile | $4,473,010 | 7 |
| Minimum | $0 | 0 |
| Maximum | $9,376,550 | 12 |

Consistent with WWQR Chapter 24: Section 26(b)(iv) requirements, the Monte Carlo-based financial assurance cost estimates: incorporate cost curves shall combine risk probabilities, event outcomes, and damages assessment to calculate expected losses under a series of events; provide estimates of 50th, 95th, 99th percentile probabilities of occurrence; are calculated by project phase; are based on cost estimates that reflect third party-performance of response actions; and account for the entire EWS Hub Project AOR.

Exhibit 11 provides a summary of results by event and cost type. Across all 50,000 Monte Carlo trials, leakage through caprock/faults then shallow wells accounted for the largest fraction of estimated costs (approximately 48.2%) followed by deep oil & gas well leak (31.5%), pipeline release (8.8%), pore space trespass (8.8%), induced seismicity (2.2%), CO2 injection well leak (0.32%) and slow leakage through caprock (0.21%). The types of costs addressed in these estimates include: well repair; USDW non-endangerment; release-related human health, ecological and infrastructure impacts; mineral rights infringement; pore space storage trespass; and, induced seismicity-related infrastructure damage.

### Exhibit 11. Cost Estimate Breakdown by Event and Cost Category Types

| Event | Associated Cost Categories | Percent of Total Costs Across All Trials |
|---|---|---|
| Leakage Through Caprock/Faults then Shallow Well | Well repair (as applicable), USDW non-endangerment, release-related human health, ecological and infrastructure impacts, mineral rights infringement | 48.2% |
| Deep Oil & Gas Well Leak | | 31.5% |
| CO2 Injection Well Leak | | 0.32% |
| Slow Leakage Through Caprock | | 0.2% |
| Rapid Leakage Through Caprock | | 0% |
| Release Through Existing Faults | | 0% |
| Release Through Induced Faults | | 0% |
| Pipeline Release | Release-related human health, ecological and infrastructure impacts | 8.8% |
| Pore Space Trespass | Pore space storage rights payment | 8.8% |
| Induced Seismicity | Seismicity-related infrastructure damage | 2.2% |

**Matthew Kern**
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matthew.kern@marsh.com

**Via Email**

May 6, 2024

Wyoming Department of Environmental Quality
200 West 17th St.
Cheyenne, Wyoming 82002

Re: Insurer Support – **Eastern Wyoming Sequestration Hub, Laramie County, WY**

To whom it may concern:

It is our pleasure to provide **Tallgrass High Plains Carbon Storage, LLC** insurance coverages to address project risks and meet their financial assurance responsibilities under the United States Environmental Protection Agency's Class VI Underground Injection Control regulations for the **Tallgrass High Plains Carbon Storage, LLC's Spirea I-1 Well Located in Laramie County** ("Project") as detailed below:

- Class VI Application: 2023-041
- Facility ID No.: WYS-021-00155
- Facility Name: Spirea I-1
- Facility Address (Coordinates): 41.052367, -104.3424469

This letter amends and supersedes the Insurer Support Letter prepared on November 27, 2023 for the Project. Marsh USA LLC, a subsidiary of Marsh McLennan, will approach carriers with AM Best ratings of A- or higher, and with size categories of VII or greater to secure bindable quotes for pollution insurance coverage. As a good faith measure of its commitment to the Class VI project, Tallgrass is providing a specimen policy with endorsements and a certificate. We will request quotes for policies conforming to these specimens with a limit of liability of $15MM (each incident) / $45MM (aggregate), as required by the Wyoming rule.

After receipt and satisfactory review of all the required underwriting data, Marsh USA LLC expects to bind the program and incept a Pollution Legal Liability insurance policy, with all applicable financial assurance endorsements attached, and the required certificate. Placing a Pollution Legal Liability policy requires an underwriting review to protect the carrier's exposure, as well as ensure that the programs they put in place (1) will comply with the Class VI Underground Injection Control regulations, and (2) protect human health and the environment - a goal enthusiastically shared by all parties involved in the Project. Marsh USA LLC and its carrier trading partners are committed to supporting the carbon capture & storage industry, and will work **Tallgrass High Plains Carbon Storage, LLC** to support the project with effective risk transfer and financial assurance. The Pollution Legal Liability will meet the requirements of the W.S. §35-11-313(f)(ii)(O) and Section 26(l)(i)(B).

Please do not hesitate to contact us with questions. We look forward to working with you.

Sincerely,



Matthew Kern
Senior Vice President
Marsh Environmental Practice

cc: Mark Webster

**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# CLAIM AND NOTICE REPORTING

This endorsement modifies insurance provided under the following:
PRIME POLLUTION LIABILITY COVERAGE FORM
PRIME PUMPER POLLUTION LIABILITY COVERAGE FORM
PRIME PLUS GENERAL LIABLITY AND POLLUTION LIABILITY COVERAGE FORM
PRIME CONTRACTORS POLLUTION LIABILITY COVERAGE FORM
EXCESS LIABILITY COVERAGE FORM

Subject to the claims and notice reporting provisions within the policy, claim and notice reports may be given in writing via:

**POSTAL SERVICE to:**
ASCOT Insurance Company
55 W. 46th Street, 26th Floor
New York, NY 10036

**E-MAIL to:**
Environmentalclaims@ascotgroup.com

or

**By phone:**
24 Hour Claims Reporting: 1-833-454-3023
24 Hour Emergency Response: 1-833-ER-ASCOT

# PRIME PUMPER POLLUTION LIABILITY

**(Pollution for Upstream, Midstream, Production, Exploration and Refining)**

## COVERAGE FORM

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# PRIME PUMPER POLLUTION LIABILITY

**(Pollution for Upstream, Midstream, Production, Exploration and Refining)**

# COVERAGE FORM

Various provisions in this policy restrict coverage. Please read the entire policy carefully to determine rights, duties and what is and is not covered.

**SECTION I – COVERAGES**, **Coverage A – Covered Location Pollution Liability** of this policy provide claims-made coverage.

Throughout this policy the words "you" and "your" refer to the Named Insured shown in the Declarations, and any other person or organization qualifying as a Named Insured under this policy. The words "we", "us" and "our" refer to the Company providing this insurance.

The word "insured" means any person or organization qualifying as such under **SECTION II – WHO IS AN INSURED**.

Defined terms, other than headings, appear in bold face type. Refer to **SECTION V - DEFINITIONS**.

**SECTION I – COVERAGES**

**Coverage A – Covered Location Pollution Liability**

**1. Insuring Agreement**

**a.** We will pay those sums that the insured becomes legally obligated to pay as damages because of **bodily injury**, **property damage** or **environmental damage** to which this insurance applies caused by or resulting from a **pollution event** on, at, under or migrating from a **covered location**. We will have the right and the duty to defend the insured against any **suit** seeking those damages. However, we will have no duty to defend the insured against any **suit** seeking damages for **bodily injury**, **property damage** or **environmental damage** to which this insurance does not apply. We may, at our discretion, investigate any **pollution event** and settle any **claim** or **suit** that may result. But:

**(1)** The amount we will pay for damages is limited as described in **Section III – LIMITS OF INSURANCE AND DEDUCTIBLE**; and

**(2)** Our right and duty to defend ends when we have used up the applicable limit of insurance in the payment of judgments, settlements, **clean-up costs** under **Coverage A** or costs under **Coverage C**.

No other obligation or liability to pay sums or perform acts or services is covered unless explicitly provided for under **SECTION I – SUPPLEMENTARY PAYMENTS**.

**b.** This insurance applies to **bodily injury**, **property damage** or **environmental damage** only if:

**(1)** The **bodily injury**, **property damage** or **environmental damage** is caused by or resulting from a **pollution event** that takes place in the **coverage territory**; and

**(2)** The **bodily injury**, **property damage** or **environmental damage** is caused by or resulting from a **pollution event** that occurs before the end of the **policy period**; and

**(3)** The insured first discovers the **pollution event** during the **policy period**. Discovery of a **pollution event** happens when a **responsible insured (i)** first becomes aware of the **pollution event**, **(ii)** reports the **pollution event** to us in writing during the **policy period** or any extended reporting period we provide under **SECTION IV – CONDITIONS**, Condition **9. Extended Reporting Period**, and **(iii)** promptly reports the **pollution event** to the appropriate governmental authority as required by **environmental law**; or

**(4)** A **claim** for damages because of **bodily injury**, **property damage** or **environmental damage** is first made against the insured and reported to us in writing during the **policy period** or any extended reporting period we provide under **SECTION IV – CONDITIONS**, Condition **9. Extended Reporting**

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**Period**. A **claim** received by the insured during the **policy period** and reported to us within 30 days after the end of the **policy period** will be considered to have been reported within the **policy period**.

**c.** If a **claim** is first made against an insured and reported to us during the **policy period**, and additional **claims** arising from the same, related or continuous **pollution event** are made against an insured and reported to us during the **policy period** or during the policy period of a subsequent policy issued by us to you providing coverage substantially the same as that provided by **Coverage A – Covered Location Pollution Liability** for **claims** first made against an insured and reported to us during the **policy period**, then all such **claims** shall be:

**(1)** Deemed to be one **claim**;

**(2)** Deemed to have been first made and reported during this **policy period** on the date the first of such **claims** was made and reported; and

**(3)** Subject to the Coverage A – Covered Location Pollution Liability Limit stated in the Declarations.

Coverage under this **Coverage A – Covered Location Pollution Liability** for such **claims** shall not apply, however, unless at the time such subsequent **claims** are first made and reported, you have maintained with us coverage substantially the same as this **Coverage A – Covered Location Pollution Liability** on a continuous, uninterrupted basis since the first such **claim** was made against an insured.

**d.** Damages because of **bodily injury** include damages claimed by any person or organization for care, loss of services or death resulting at any time from the **bodily injury**.

**2. Exclusions**

In addition to exclusions found in **SECTION I – COMMON EXCLUSIONS**, this insurance does not apply to:

**a. Damage to Mode of Transportation**

**Property damage** to any **mode of transportation** utilized during **transportation**. This exclusion does not apply to **claims** made by third-party carriers for such **property damage** arising from the insured's negligence.

**b. Change in Use**

**Clean-up costs** required by **environmental law** due to a change in zoning or permitted use of any **covered location** during the **policy period**.

However, this exclusion does not apply to a **non-owned location** or a **divested location**.

**c. Construction Activities**

**Environmental damage** caused by or resulting from **pollutants** or a **pollution event** discovered during **construction activities** at a **covered location**.

**d. Intrusive Investigation**

**Environmental damage** caused by or resulting from a **pollution event** discovered during **intrusive investigation** at a **covered location** during the **policy period**.

However, this exclusion does not apply to a **non-owned location**.

**e. Landfill or Impoundment**

Costs, charges and expenses, incurred to investigate, remove, dispose of, abate, contain, treat, neutralize, monitor or test contaminated soil or other media in a landfill cell or an impoundment.

However, this exclusion does not apply to a **non-owned location**.

**f. Prior Known Pollution Event**

**Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** or a **recognized environmental condition** known to a **responsible insured** prior to **(i)** the

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effective date of the **policy period** or **(ii)** the effective date of an Endorsement to this policy adding a **covered location**.

This exclusion does not apply if:

**(1)** The **pollution event** known to a **responsible insured** did not meet reporting requirements under **environmental law**;

**(2)** A No Further Action (NFA) or equivalent decision has been documented in writing in accordance with **environmental law** as respects the **pollution event** or **recognized environmental condition** giving rise to the **bodily injury**, **property damage** or **environmental damage**;

**(3)** We have been notified in writing of such **pollution event** giving rise to the **bodily injury**, **property damage** or **environmental damage** during the policy period of a policy previously issued by us to you; or

**(4)** The **pollution event** or **recognized environmental condition** giving rise to the **bodily injury**, **property damage** or **environmental damage** is specifically referenced, or identified on a Prior Known Pollution Event Exclusion Amendment Endorsement attached to this policy.

**Coverage B - Miscellaneous Pollution Liability**

**1. Insuring Agreement**

**a.** We will pay those sums that the insured becomes legally obligated to pay as damages, to which this insurance applies, because of:

**(1) Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** arising out of **your work** scheduled to this policy by Endorsement;

**(2) Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** during **transportation**; or

**(3) Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **time-element pollution event** on, at, under or migrating from a **newly acquired location**.

**b.** We will have the right and duty to defend the insured against any **suit** seeking those damages. However, we will have no duty to defend the insured against any **suit** seeking damages to which this insurance does not apply. We may, at our discretion, investigate any **pollution event** and settle any **claim** or **suit** that may result. But:

**(1)** The amount we will pay for damages is limited as described in **SECTION III - LIMITS OF INSURANCE AND DEDUCTIBLE**; and

**(2)** Our right and duty to defend ends when we have used up the applicable limits of insurance in the payment of judgments, settlements, **clean-up costs** under **Coverage A** or costs under **Coverage C**.

No other obligation or liability to pay sums or perform acts or services is covered unless explicitly provided for under **SECTION I – SUPPLEMENTARY PAYMENTS**.

**c.** This insurance applies to **bodily injury**, **property damage** or **environmental damage** only if:

**(1)** The **bodily injury**, **property damage** or **environmental damage** is caused by or resulting from a **pollution event** that takes place in the **coverage territory**;

**(2)** The **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** arising out of **your work** occurs during the **policy period**; and

**(3)** Prior to the **policy period**, no **responsible insured** knew that the **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** arising out of **your work** had occurred, in whole or in part. If any **responsible insured** knew, prior to the **policy period**, that the **bodily injury**, **property damage** or **environmental damage** occurred, then any continuation, change or resumption of such **bodily injury**, **property damage** or **environmental damage** during or after the **policy period** will be deemed to have been known prior to the **policy period**. However,

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this does not apply to any continuation, change or resumption of **environmental damage** arising out of **your work** performed after the effective date of the **policy period**;

**(4)** The **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** during **transportation** occurs before the end of the **policy period**; and

**(5)** No **claim** for such **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** during **transportation** was made against the insured prior to the effective date of the **policy period**;

**(6)** The **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **time-element pollution event** on, at under or migrating from a **newly acquired location** occurs during the **policy period**.

**d.** **Bodily injury**, **property damage** or **environmental damage** will be deemed to have been known to have occurred at the earliest time when any **responsible insured**:

**(1)** Reports all, or any part, of the **bodily injury, property damage** or **environmental damage** to us or any other insurer;

**(2)** Receives a **claim** or **suit** for damages because of the **bodily injury**, **property damage** or **environmental damage**; or

**(3)** Becomes aware by any other means that **bodily injury**, **property damage** or **environmental damage** has occurred or has begun to occur.

**e.** The following applies to progressive or indivisible **bodily injury**, **property damage** or **environmental damage**, including any continuation, change or resumption of such **bodily injury**, **property damage** or **environmental damage**, which takes place over a period of days, weeks, months or longer caused by continuous or repeated exposure to the same, related or continuous **pollution event**:

**(1)** Such **bodily injury**, **property damage** or **environmental damage** shall be deemed to have taken place only on the date of first exposure to such **pollution event**; or

**(2)** Such **bodily injury**, **property damage** or **environmental damage** shall be deemed to have taken place during the policy period of the first policy issued by us to you providing coverage substantially the same as that provided by **Coverage B – Miscellaneous Pollution Liability** of this policy for **bodily injury**, **property damage** or **environmental damage** that takes place during the **policy period** but only if:

**(a)** The date of first exposure cannot be determined or is before the effective date of the first policy issued by us to you providing coverage substantially the same as that provided by **Coverage B – Miscellaneous Pollution Liability** of this policy for **bodily injury**, **property damage** or **environmental damage** that takes place during the **policy period**; and

**(b)** Such **bodily injury**, **property damage** or **environmental damage** continues, in fact, to occur during this **policy period**.

**f.** If the same, related or continuous **pollution event** results in **bodily injury**, **property damage** or **environmental damage** that takes place during the policy periods of different policies issued by us to you providing coverage substantially the same as that provided by **Coverage B – Miscellaneous Pollution Liability** of this policy for **bodily injury**, **property damage** or **environmental damage** that takes place during the **policy period**:

**(1)** All such **bodily injury**, **property damage** and **environmental damage** shall be deemed to have taken place only during the first policy period of such policies in which any of the **bodily injury**, **property damage** or **environmental damage** took place; and

**(2)** All damages arising from all such **bodily injury**, **property damage** or **environmental damage** shall be deemed to have arisen from one **pollution event** and shall be subject to the Coverage B – Miscellaneous Pollution Liability Limit applicable to the policy for such first policy period.

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**g.** Damages because of **bodily injury** include damages claimed by any person or organization for care, loss of services or death resulting at any time from the **bodily injury**.

**2. Exclusions**

In addition to exclusions found in **SECTION I – COMMON EXCLUSIONS**, this insurance does not apply to:

**a. Covered Location Transportation**

**Environmental damage** caused by or resulting from a **pollution event** during **transportation** within the boundaries of a **covered location**.

**b. Damage to Mode of Transportation**

**Property damage** to any **mode of transportation** utilized during **transportation**. This exclusion does not apply to **claims** made by third-party carriers for such **property damage** arising from the insured's negligence.

**c. Damage to Your Work**

**Property damage** or **environmental damage** to that particular part of any property on which you are performing **your work** if the **property damage** or **environmental damage** arises out of **your work**.

This exclusion does not apply if the damaged work or the work out of which the damage arises was performed on your behalf by a subcontractor.

**d. Disposal Site**

**Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** on, at, under or migrating from any transfer, storage, disposal, landfill, treatment or consolidation **location** beyond the boundary of a job site where **your work** is performed.

**Coverage C - Emergency and Crisis Management Costs**

**1. Insuring Agreement**

**a.** We will pay **emergency costs** incurred by or on behalf of the insured in response to an imminent or substantial threat to human health or the environment caused by or resulting from a **pollution event**:

**(1)** Arising out of **your work**;

**(2)** During **transportation**; or

**(3)** On, at, under or migrating from a **covered location** or a **newly acquired location**.

**b.** But only if:

**(1)** The **pollution event** first commenced during the **policy period**;

**(2)** The **pollution event** takes place in the **coverage territory**;

**(3)** The **emergency costs**, except for **crisis management costs**, are incurred within ten business days of commencement of the **pollution event**; or

**(4)** The **crisis management costs** are incurred within six months of commencement of the **pollution event**; and

**(5)** The **pollution event** and related **emergency costs** are reported to us in writing within 30 business days of commencement of the **pollution event**.

**c.** We will pay these costs regardless of fault. But the amount we will pay is limited as described in **SECTION III - LIMITS OF INSURANCE AND DEDUCTIBLE**.

No other obligation or liability to pay sums or perform acts or services is covered unless explicitly provided for under **SECTION I – SUPPLEMENTARY PAYMENTS**.

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**2. Exclusions**

In addition to exclusions found in **SECTION I – COMMON EXCLUSIONS** and **Coverage A – Covered Location Pollution Liability**, this insurance does not apply to:

**a. Divested Location**

**Emergency costs** incurred as a result of a **pollution event** on, at, under or migrating from a **divested location**.

**b. Non-Owned Location**

**Emergency costs** incurred as a result of a **pollution event** on, at, under or migrating from a **non-owned location**.

**SECTION I – COMMON EXCLUSIONS**

The insurance provided in **SECTION I** does not apply to:

**1. Asbestos and Lead**

**Environmental damage** caused by, resulting from, arising out of or related to, in whole or in part, the actual, alleged, threatened or suspected presence or existence of asbestos, asbestos containing materials, lead or lead containing materials in, on, or applied to any building or other structure.

However, this exclusion does not apply to **environmental damage** to land, any **mode of transportation**, the atmosphere, any watercourse or body of water including surface water or groundwater.

**2. Closure Costs**

Any cost, charges and expenses for closure, post closure, reclamation or plug and abandonment of well activities or obligations.

**3. Contractual Liability**

**Bodily injury**, **property damage** or **environmental damage** for which the insured is obligated to pay damages by reason of the assumption of liability in a contract or agreement. This exclusion does not apply to liability for damages:

**a.** That the insured would have in the absence of the contract or agreement; or

**b.** Assumed in a contract or agreement that is an **insured contract**, provided the **bodily injury**, **property damage** or **environmental damage** occurs subsequent to the execution of the contract or agreement. Solely for the purposes of liability assumed in an **insured contract**, reasonable attorneys' fees and necessary litigation expenses incurred by or for a party other than an insured are deemed to be damages because of **bodily injury**, **property damage** or **environmental damage**, provided:

**(1)** Liability to such party for, or for the cost of, that party's defense has also been assumed in the same **insured contract**; and

**(2)** Such attorneys' fees and litigation expenses are for defense of that party against a civil or alternative dispute resolution proceeding in which damages to which this insurance applies are alleged.

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**4. Drilling and Specialty Equipment**

**Property damage** to drilling, work-over or servicing equipment.

**5. Employer's Liability**

**Bodily injury** to:

**a.** An **employee** of the insured arising out of and in the course of employment by the insured or performing duties related to the conduct of the insured's business; or

**b.** The spouse, child, parent, brother or sister of that **employee** as a consequence of Paragraph **a.** above.

This exclusion applies whether the insured may be liable as an employer or in any other capacity and to any obligation to share damages with or repay someone else who must pay damages because of the injury.

This exclusion does not apply to liability assumed by the insured under an **insured contract**.

**6. Expected or Intended Injury or Damage**

**Bodily injury**, **property damage** or **environmental damage** expected or intended from the standpoint of the insured.

However, this exclusion does not apply to **property damage** or **environmental damage** caused by or resulting from response to an imminent and substantial threat to human health or the environment.

**7. Noncompliance**

**Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **responsible insured's** intentional disregard of, or deliberate, knowing, willful or dishonest noncompliance with any **environmental law**.

However, this exclusion does not apply to **bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **responsible insured's** knowing or willful noncompliance with any **environmental law** in response to an imminent and substantial threat to human health or the environment.

**8. Nuclear Material**

**Bodily injury**, **property damage** or **environmental damage** caused by, resulting from, arising out of or related to, in whole or in part, the radioactive, toxic or explosive properties of **nuclear material** but only if the insured is:

**a.** Required to maintain financial protection pursuant to the Atomic Energy Act of 1954;

**b.** Entitled to indemnity from the United States of America or any agency thereof; or

**c.** An insured under a nuclear energy liability policy issued by Nuclear Energy Liability Insurance Association, Mutual Atomic Energy Liability Underwriters, Nuclear Insurance Association of Canada or any of their successors, or would be an insured under any such policy but for its termination upon exhaustion of limits.

**9. Subsurface Storage of Natural Gas**

**Bodily injury**, **property damage** or **environmental damage** that results from or is associated with the storage of natural gas in an underground storage facility including but not limited to depleted reservoirs in oil and gas fields, aquifers, salt caverns, salt domes, hard-rock caverns and mines.

**10. Underground Storage Tanks**

**Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** originating from or arising out of an **underground storage tank** which is: **(i)** known to a **responsible insured** as of the effective date of the **policy period**; **(ii)** known to a **responsible insured** as of the date of acquisition or initial occupancy of a **newly acquired location**; **(iii)** known to a **responsible insured** as of the date a **covered location** is added by Endorsement during the **policy period**; or **(iv)** installed during the **policy period**.

This exclusion does not apply to an **underground storage tank** which has been:

**a.** Closed, abandoned in place or removed in accordance with all applicable **environmental laws**; or

**b.** Scheduled to this policy by Endorsement.

**11. Upgrades, Improvements or Installations**

Any costs, charges or expenses for upgrade to, improvement of, or installation of any control of:

**a.** Any personal property on a **covered location**; or

**b.** Processes on, within or under a **covered location**.

This exclusion applies even if such upgrade, improvement or installation is required by **environmental law**.

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**12. War**

**Bodily injury**, **property damage** or **environmental damage**, however caused, arising, directly or indirectly, out of:

**a.** War, including undeclared or civil war;

**b.** Warlike action by a military force, including action in hindering or defending against an actual or expected attack, by any government, sovereign or other authority using military personnel or other agents; or

**c.** Insurrection, rebellion, revolution, usurped power, or action taken by governmental authority in hindering or defending against any of these.

**13. Workers' Compensation and Similar Laws**

Any obligation of the insured under a workers' compensation, disability benefits or unemployment compensation law or any similar law.

**SECTION I – SUPPLEMENTARY PAYMENTS**

**1.** We will pay, with respect to any **claim** we investigate or settle, any **suit** against an insured we defend, or any **emergency costs** incurred by or on behalf of any insured:

**a.** All expenses we incur that are directly allocated to a particular **claim** or **suit**.

**b.** All attorneys' fees or attorneys' expenses incurred by the insured in connection with **emergency costs**.

**c.** All reasonable expenses incurred by the insured at our request to assist us in the investigation or defense of the **claim** or **suit**, including actual loss of earnings up to $500 a day because of time off from work.

**d.** All court costs taxed against the insured in the **suit**. However, these payments do not include attorneys' fees or attorneys' expenses taxed against the insured.

**e.** Prejudgment interest awarded against the insured on that part of the judgment we pay. If we make an offer to pay the applicable limit of insurance, we will not pay any prejudgment interest based on that period of time after the offer.

**f.** All interest on the full amount of any judgment that accrues after entry of the judgment and before we have paid, offered to pay, or deposited in court the part of the judgment that is within the applicable limit of insurance.

These payments will not reduce the limits of insurance.

**2.** If we defend an insured against a **suit** and an indemnitee of the insured is also named as a party to the **suit**, we will defend that indemnitee if all of the following conditions are met:

**a.** The **suit** against the indemnitee seeks damages for which the insured has assumed the liability of the indemnitee in a contract or agreement that is an **insured contract**;

**b.** This insurance applies to such liability assumed by the insured;

**c.** The obligation to defend, or the cost of the defense of, that indemnitee, has also been assumed by the insured in the same **insured contract**;

**d.** The allegations in the **suit** and the information we know about the **pollution event** are such that no conflict appears to exist between the interests of the insured and the interests of the indemnitee;

**e.** The indemnitee and the insured ask us to conduct and control the defense of the indemnitee against such **suit** and agree that we can assign the same counsel to defend the insured and the indemnitee; and

**f.** The indemnitee:

**(1)** Agrees in writing to:

**(a)** Cooperate with us in the investigation, settlement or defense of the **suit**;

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**(b)** Immediately send us copies of any demands, notices, summonses or legal papers received in connection with the **suit**;

**(c)** Notify any other insurer whose coverage is available to the indemnitee; and

**(d)** Cooperate with us with respect to coordinating other applicable insurance available to the indemnitee; and

**(2)** Provides us with written authorization to:

**(a)** Obtain records and other information related to the **suit**; and

**(b)** Conduct and control the defense of the indemnitee in such **suit**.

So long as the above conditions are met, attorneys' fees incurred by us in the defense of that indemnitee, necessary litigation expenses incurred by us and necessary litigation expenses incurred by the indemnitee at our request will be paid as **SECTION I – SUPPLEMENTARY PAYMENTS**. Notwithstanding the provisions of **SECTION I – COMMON EXCLUSIONS**, Exclusion **3. Contractual Liability**, Paragraph **b.**, such payments will not be deemed to be damages for **bodily injury**, **property damage** and **environmental damage** and will not reduce the limits of insurance.

Our obligation to defend an insured's indemnitee and to pay for attorneys' fees and necessary litigation expenses as **SECTION I – SUPPLEMENTARY PAYMENTS** ends when we have used up the applicable limit of insurance in the payment of judgments or settlements; or the conditions set forth above, or the terms of the agreement described in Paragraph **f.** above, are no longer met.

**SECTION II – WHO IS AN INSURED**

**1.** If you are designated in the Declarations as:

**a.** An individual, you and your spouse are insureds, but only with respect to the conduct of a business of which you are the sole owner.

**b.** A partnership or joint venture, you are an insured. Your members, your partners, and their spouses are also insureds, but only with respect to the conduct of your business.

**c.** A limited liability company, you are an insured. Your members are also insureds, but only with respect to the conduct of your business. Your managers are insureds, but only with respect to their duties as your managers.

**d.** An organization other than a partnership, joint venture or limited liability company, you are an insured. Your **executive officers** and directors are insureds, but only with respect to their duties as your officers or directors. Your stockholders are also insureds, but only with respect to their liability as stockholders.

**e.** A trust, you are an insured. Your trustees are also insureds, but only with respect to their duties as trustees.

**2.** Any subsidiary, associated, affiliated, allied or limited liability company or corporation, including subsidiaries thereof, over which you maintain ownership or majority interest as of the effective date of the **policy period** qualify as a Named Insured.

**3.** Any organization you newly acquire or form, other than a partnership, joint venture or limited liability company, and over which you maintain ownership or majority interest, will qualify as a Named Insured if there is no other similar insurance available to that organization. However, coverage under this policy does not apply to **bodily injury**, **property damage** or **environmental damage** that occurred before you acquired or formed the organization.

**4.** Each of the following is also an insured:

**a.** Your **volunteer workers** only while performing duties related to the conduct of your business, or your **employees**, other than either your **executive officers** (if you are an organization other than a partnership, joint venture or limited liability company) or your managers (if you are a limited liability company), but only for acts within the scope of their employment by you or while performing duties

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related to the conduct of your business. However, none of these **employees** or **volunteer workers** are insureds for:

**(1) Bodily injury**:

**(a)** To you, to your partners or members (if you are a partnership or joint venture) or to your members (if you are a limited liability company); or

**(b)** For which there is any obligation to share damages with or repay someone else who must pay damages because of the injury described in Paragraphs **(1)(a)** above.

**(2) Property damage** or **environmental damage** to property owned, occupied or used by, rented to, in the care, custody or control of, or over which physical control is being exercised for any purpose by you, any of your **employees**, **volunteer workers**, any partner or member (if you are a partnership or joint venture), or any member (if you are a limited liability company).

**b.** Any person (other than your **employee**), or any organization while acting as your real estate manager.

**c.** Any person or organization having proper temporary custody of your property if you die, but only with respect to liability arising out of the maintenance or use of that property and until your legal representative has been appointed.

**d.** Your legal representative if you die, but only with respect to duties as such. That representative will have all your rights and duties under this policy.

**e.** Any person(s) or organization(s) for whom you have agreed in writing in a contract, agreement or permit that such person(s) or organization(s) be added as an additional insured on your policy. Such person(s) or organization(s) is an additional insured only with respect to liability for **bodily injury**, **property damage** or **environmental damage** caused, in whole or in part, by:

**(1)** Your acts or omissions or the acts or omissions of those acting on your behalf in connection with a **covered location** or **newly acquired location**;

**(2) Your work**;

**(3)** Your ownership, maintenance, operation or use of a **covered location** or **newly acquired location**.

However, the insurance afforded to such additional insured only applies to the extent permitted by law and will not be broader than that which you are required by the contract, agreement or permit to provide for such additional insured.

**f.** Any owner, co-owner, party of joint venture, mining partner or limited liability company having a non-operating working interest in any oil or gas lease of which you are the operator, but only with respect to their liability for **bodily injury**, **property damage** or **environmental damage** arising out of such non-operating working interest.

**g.** Any person or organization that has a controlling interest in you, but only with respect to their liability for **bodily injury**, **property damage** or **environmental damage** arising out of their financial control of you.

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**SECTION III – LIMITS OF INSURANCE AND DEDUCTIBLE**

**1.** The Limits of Insurance shown in the Declarations and the rules below fix the most we will pay regardless of the number of:

**a.** Insureds;

**b. Claims** made or **suits** brought;

**c.** Persons or organizations making **claims** or bringing **suits**; or

**d. Pollution events**.

**2.** The Policy Aggregate Limit is the most we will pay for the sum of all damages, **clean-up costs** and **emergency costs** under **Coverages A** through **C** inclusive.

**3.** Subject to Paragraph **2.** above, the Coverage A - Covered Location Pollution Liability Limit is the most we will pay for the sum of all damages and **clean-up costs** under **Coverage A - Covered Location Pollution Liability** because of all **bodily injury**, **property damage** and **environmental damage** caused by or resulting from the same, related or continuous **pollution event**.

**4.** Subject to Paragraph **2.** above, the Coverage B - Miscellaneous Pollution Liability Limit is the most we will pay for the sum of all damages under **Coverage B - Miscellaneous Pollution Liability** because of all **bodily injury, property damage** and **environmental damage** caused by or resulting from the same, related or continuous **pollution event**.

**5.** Subject to Paragraph **2.** Above, the Coverage C - Emergency and Crisis Management Costs Limit is the most we will pay under **Coverage C - Emergency and Crisis Management Costs** for the sum of all **emergency costs** incurred arising from the same, related or continuous **pollution event**.

**6.** The Limits of Insurance apply in excess of the Deductible amounts shown in the Declarations. The deductible amount applies as follows:

**a.** As respects Coverage A - Covered Location Pollution Liability Limit, to the sum of all damages and **clean-up costs** and any payments made under **SECTION I – SUPPLEMENTARY PAYMENTS** because of **bodily injury**, **property damage** or **environmental damage** caused by or resulting from the same, related or continuous **pollution event**.

**b.** As respects Coverage B - Miscellaneous Pollution Liability Limit, to the sum of all damages and any payments made under **SECTION I – SUPPLEMENTARY PAYMENTS** because of **bodily injury**, **property damage** or **environmental damage** caused by or resulting from the same, related or continuous **pollution event**.

**c.** As respects Coverage C – Emergency and Crisis Management Costs Limit, to the sum of all **emergency costs** incurred and any payments made under **SECTION I – SUPPLEMENTARY PAYMENTS** arising from the same, related or continuous **pollution event**.

However, if this insurance applies on an excess basis as described in **SECTION IV – CONDITIONS**, Condition **14. Other Insurance**, Paragraph **b. Excess Insurance**, the Deductible amounts shown in the Declarations will be eroded by any such valid and collectible other insurance.

We may pay any part or the entire deductible amount to effect settlement of any **claim** or **suit** or to pay **clean-up costs** or **emergency costs** which may be covered under this policy and, upon notification of the action taken, you shall promptly reimburse us for such part of the deductible amount as has been paid by us.

If the same or related **pollution event** results in coverage under more than one Coverage Part, only the highest deductible under any one Coverage Part will apply.

**7.** The Limits of Insurance apply to the entire **policy period**. If the **policy period** is extended after policy issuance for an additional period, the additional period will be deemed part of the last preceding period for the purposes of determining the Limits of Insurance.

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**SECTION IV – CONDITIONS**

**1. Bankruptcy**

Bankruptcy or insolvency of the insured or of the insured's estate will not relieve us of our obligations under this policy.

**2. Cancellation**

**a.** The first Named Insured shown in the Declarations may cancel this policy by mailing or delivering to us advance written notice of cancellation.

**b.** We may cancel this policy by mailing or delivering to the first Named Insured written notice of cancellation at least:

**(1)** Ten days before the effective date of cancellation if we cancel for nonpayment of premium; or

**(2)** Ninety days before the effective date of cancellation if we cancel for any other reason.

**c.** We will mail or deliver our notice to the first Named Insured's last mailing address known to us.

**d.** Notice of cancellation will state the effective date of cancellation. The **policy period** will end on that date.

**e.** If this policy is cancelled, we will send the first Named Insured any premium refund due. If we cancel, the refund will be pro rata. If the first Named Insured cancels, the refund will be less than pro rata and will be subject to the minimum earned premium stated in the Declarations. The cancellation will be effective even if we have not made or offered a refund.

**f.** If notice is mailed, proof of mailing will be sufficient proof of notice.

**3. Changes**

This policy contains all the agreements between you and us concerning the insurance afforded. The first Named Insured shown in the Declarations is authorized to make changes in the terms of this policy with our consent. This policy's terms can be amended or waived only by endorsement issued by us and made a part of this policy.

**4. Choice of Forum**

In the event that the insured and we have any dispute concerning or relating to this policy, including its formation, coverage provided hereunder, or the meaning, interpretation or operation of any term, condition, definition or provision of this policy resulting in litigation, arbitration or other form of dispute resolution, the insured agrees with us that any such litigation, arbitration or other form of dispute resolution shall take place in the appropriate federal or state courts located in New York, New York.

**5. Choice of Law**

In the event that the insured and we have any dispute concerning or relating to this policy, including its formation, coverage provided hereunder, or the meaning, interpretation or operation of any term, condition, definition or provision of this policy resulting in litigation, arbitration or other form of dispute resolution, the insured agrees with us that the internal laws of the State of New York shall apply without giving effect to any conflicts or choice of law principles. The terms and conditions of this policy shall not be deemed to constitute a contract of adhesion and shall not be construed in favor of or against any party hereto by reason or authorship or otherwise.

**6. Currency**

All reimbursement shall be made in United States currency at the rate of exchange prevailing on the date of judgment if judgment is rendered, the date of settlement if settlement is agreed upon with our written consent or the date of payment of **clean-up costs** and **emergency costs**, whichever is applicable.

**7. Duties in the Event of a Pollution Event, Claim or Suit**

**a.** Without limiting the requirements of any insuring agreement in this policy, you must see to it that we are notified as soon as practicable of a **pollution event** which may result in a **claim** or is reasonably likely to involve this policy. To the extent possible, notice should include:

**(1)** How, when and where the **pollution event** took place;

**(2)** The names and addresses of any injured persons and witnesses; and

**(3)** The nature and location of any injury or damage arising out of the **pollution event**.

**b.** If a **claim** is made or **suit** is brought against any insured, you must:

**(1)** Immediately record the specifics of the **claim** or **suit** and the date received; and

**(2)** Notify us as soon as practicable.

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You must see to it that we receive written notice of the **claim** or **suit** as soon as practicable.

**c.** You and any other involved insured must:

**(1)** Immediately send us copies of any demands, notices, summonses or legal papers received in connection with the **claim** or **suit**;

**(2)** Immediately send us copies of contracts, certificates of insurance, environmental site assessments and any other documents deemed pertinent by us to the **claim** or **suit**;

**(3)** Authorize us to obtain records and other information;

**(4)** Cooperate with us in the investigation or settlement of the **claim** or defense against the **suit**; and

**(5)** Assist us, upon our request, in the enforcement of any right against any person or organization which may be liable to the insured because of injury or damage to which this insurance may also apply.

**d.** In the event **emergency costs** are incurred, you must provide, in writing, all available information relating to such **emergency costs** and the **pollution event** giving rise thereto to us within 30 days of commencement of the pollution event.

**e.** In the event of a **time-element pollution event**, you must provide, in writing, all available information relating to the **pollution event** giving rise thereto to us within 30 days of commencement of the **pollution event**.

**f.** No insured will, except at that insured's own cost, voluntarily make a payment, assume any obligation, or incur any expense, other than **emergency costs**, without our consent.

**g.** When any insured becomes legally obligated to pay **clean-up costs** to which this insurance applies, the insured must:

**(1)** Submit, for our approval, all proposed work plans prior to submittal to any regulatory agency.

**(2)** Submit, for our approval, all bids and contracts for **clean-up costs** prior to execution or issuance.

**(3)** Forward progress submittals regarding **clean-up costs** at reasonable intervals and always prior to submittal to any regulatory agency that is authorized to review and approve such submittals.

We shall have the right, but not the duty, to assume direct control of such **clean-up costs**. Any **clean-up costs** incurred by us shall be applied against the applicable Limit of Insurance and deductible.

**h.** If we are prohibited under applicable law from investigating, defending or settling any such **claim** or **suit,** the insured shall, under our supervision, arrange for such investigation and defense thereof as is reasonably necessary, and subject to our prior authorization, shall effect such settlement thereof.

**8. Economic and Trade Sanctions**

In accordance with laws and regulation of the United States concerning economic and trade sanctions administered and enforced by The Office of Foreign Assets Control (OFAC), this policy is void ab initio solely with respect to any term or condition of this policy that violates any laws or regulations of the United States concerning economic and trade sanctions.

**9. Extended Reporting Period**

This condition applies only as respects **Coverage A – Covered Location Pollution Liability**.

**a.** This condition applies only if:

**(1)** The policy is cancelled or non-renewed for any reason except non-payment of the premium; or

**(2)** We renew or replace this policy with **Coverage A – Covered Location Pollution Liability** that provides claims-made coverage for **bodily injury**, **property damage** or **environmental damage** and that has a Retroactive Date; and

**(3)** You do not purchase coverage to replace the coverage described in Paragraph **a.(2)** above.

**b.** Automatic Extended Reporting Period

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You shall automatically have a period of 90 days following the effective date of such termination of coverage in which to provide written notice to us of **claims** first made and reported within the automatic extended reporting period.

A **claim** first made and reported within the automatic extended reporting period will be deemed to have been made on the last day of the **policy period**, provided that the **claim** is for damages or **clean-up costs** arising from a **pollution event** which commenced before the end of the **policy period** and is otherwise covered by this policy.

No part of the automatic extended reporting period shall apply if the optional extended reporting period is purchased.

**c.** Extended Reporting Period Option:

**(1)** A **claim** first made and reported within 48 months after the end of the **policy period** will be deemed to have been made on the last day of the **policy period**, provided that the **claim** is for damages or **clean-up costs** arising from a **pollution event** which commenced before the end of the **policy period** and is otherwise covered by this policy.

**(2)** The Extended Reporting Period Endorsement will not reinstate or increase the Limits of Insurance or extend the **policy period**.

**d.** We will issue the Endorsement indicating the Extended Reporting Period Option has been accepted if the first Named Insured shown in the Declarations:

**(1)** Makes a written request for it within 30 days after the end of the **policy period**; and

**(2)** Promptly pays the additional premium, which will not exceed 200% of the policy premium, when due.

The Extended Reporting Period Endorsement will not take effect unless the additional premium is paid when due. If that premium is paid when due, the Endorsement may not be cancelled. The additional premium will be fully earned when the Endorsement takes effect.

**e.** The Extended Reporting Period Endorsement will also amend **SECTION IV – CONDITIONS**, Condition **14. Other Insurance** so the insurance provided will be excess over any other valid and collectible insurance available to the insured, whether primary, excess, contingent or on any other basis, whose policy period begins or continues after the Endorsement takes effect.

**10. First Named Insured Duties**

The first Named Insured shown in the Declarations:

**a.** Is responsible for the payment of all premiums;

**b.** Will act on behalf of all other Named Insureds for giving and receiving of notice of cancellation;

**c.** Will be the payee for any return premiums that may become payable.

**11. Independent Counsel**

In the event the insured is entitled by law to select independent counsel to oversee our defense of a **claim** or **suit** at our expense, the attorney fees and all other litigation expenses we must pay to that counsel are limited to the rates we actually pay to counsel we retain in the ordinary course of business in the defense of similar **claims** or **suits** in the community where the **claim** or **suit** arose or is being defended.

Additionally, we may exercise the right to require that such counsel have certain minimum qualifications with respect to their competency including experience in defending **claims** or **suits** similar to the one pending against the insured and to require such counsel have a specific minimum amount of errors and omissions insurance coverage. As respects any such counsel, the insured agrees that counsel will timely respond to our request for information regarding the **claims** or **suit**.

Furthermore, the insured may at any time, by the insured's written consent, freely and fully waive these rights to select independent counsel.

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**12. Inspections and Surveys**

**a.** We have the right but not the duty to make inspections and surveys at any time, report on the conditions we find and recommend changes.

**b.** We are not obligated to make any inspections, surveys, reports or recommendations and any such actions we do undertake relate only to insurability and the premiums to be charged. We do not make safety inspections. We do not undertake to perform the duty of any person or organization to provide for the health or safety of workers or the public. We do not warrant that conditions are safe, healthful or comply with laws, regulations, codes or standards.

This applies not only to us, but also to any rating, advisory, rate service or similar organization which makes insurance inspections, surveys, reports or recommendations.

**13. Legal Action Against Us**

No person or organization has a right under this policy:

**a.** To join us as a party or otherwise bring us into a **suit** asking for damages from an insured; or

**b.** To sue us on this policy unless all of its terms have been fully complied with.

A person or organization may sue us to recover on an agreed settlement or on a final judgment against an insured; but we will not be liable for damages that are not payable under the terms of this policy or that are in excess of the applicable limit of insurance. An agreed settlement means a settlement and release of liability signed by us, the insured and the claimant or the claimant's legal representative.

**14. Other Insurance**

If other valid and collectible insurance is available to the insured for a loss we cover under this policy, our obligations are limited as follows:

**a. Primary Insurance**

This insurance is primary except when Paragraph **b.** below applies. If this insurance is primary, our obligations are not affected unless any of the other insurance is also primary. Then, we will share with all that other insurance by the method described in Paragraph **c.** below. However, regardless of whether **b.** below applies, in the event that a written contract or agreement or permit requires this insurance to be primary for any person or organization you agreed to insure and such person or organization is an insured under this policy, we will not seek contributions from any such other insurance issued to such person or organization.

**b. Excess Insurance**

**(1)** This insurance is excess over:

**(a)** Any other insurance, whether primary, excess, contingent or on any other basis that covers your liability for **bodily injury**, **property damage** or **environmental damage** arising from a **pollution event**;

**(b)** Any other insurance, whether primary, excess, contingent or on any other basis, available to you covering liability for damages caused by or resulting from a **pollution event** during **transportation**;

**(c)** Any other insurance, whether primary, excess, contingent or on any other basis, available to you covering liability for damages at a **covered location**, for which you have been added as an additional insured; or

**(d)** Any project specific primary insurance available to you covering liability for damages arising out of **your work**, for which you are an insured.

**(2)** When this insurance is excess, we will have no duty to defend the insured against any **suit** if any other insurer has a duty to defend the insured against that **suit**. If no other insurer defends, we will undertake to do so, but we will be entitled to the insured's rights against all those other insurers.

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**(3)** When this insurance is excess over other insurance, we will pay only our share of the amount of the loss, if any, that exceeds the sum of:

**(a)** The total amount that all such other insurance would pay for the loss in the absence of this insurance; and

**(b)** The total of all deductible and self-insured amounts under all that other insurance; and

**(c)** The Deductible amounts shown in the Declarations of this policy less the total amount pay in Paragraph **(a)** above.

**(4)** We will share the remaining loss, if any, with any other insurance that is not described in this Excess Insurance provision and was not bought specifically to apply in excess of the Limits of Insurance shown in the Declarations of this policy.

**c. Method of Sharing**

If other insurance is also primary, then we will share with all that other insurance by an equal share contribution method. Under this approach each insurer contributes equal amounts, excess of applicable deductible and self-insured amounts under all such insurance, until it has paid its applicable limit of insurance or none of the loss remains, whichever comes first.

**15. Representations**

By accepting this policy, you agree:

**a.** The statements in the Declarations are accurate and complete;

**b.** Those statements are based upon representations you made to us; and

**c.** We have issued this policy in reliance upon your representations.

**16. Separation of Insureds**

Except with respect to the Limits of Insurance and any rights or duties specifically assigned in this policy to the first Named Insured, this insurance applies:

**a.** As if each Named Insured were the only Named Insured; and

**b.** Separately to each insured against whom **claim** is made or **suit** is brought.

**17. Service of Suit**

It is hereby understood and agreed that we may be sued upon any cause of action arising under any insurance contract made by us or evidence of insurance issued or delivered by the broker, in the courts for the county(s) where the insurance provides coverage or in the courts of New York, New York where we maintain our home office.

It is further agreed that service of process in such suit may be made upon the Superintendent, Commissioner, Director of Insurance or other appropriate person at the state Department of Insurance, Secretary of State or other designee as provided for in specific state laws and/or regulations.

When service of process is made upon a statutory designee according to state law, such process should be provided via certified mail to us to the attention of our General Counsel.

It is further agreed that in any **suit** instituted against any insured under this policy or otherwise upon this policy, we will abide by the final decision of such court or of any appellate court in the event of an appeal.

**18. Transfer of Rights of Recovery Against Others to Us**

If the insured has rights to recover all or part of any payment we have made under this policy, those rights are transferred to us. The insured must do nothing after loss to impair them. At our request, the insured will bring **suit** or transfer those rights to us and help us enforce them. However, if the insured has waived rights of recovery against any person or organization, in writing, prior to a loss, we waive any right of recovery we may have under this policy against such person or organization.

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**19. Transfer of Your Rights and Duties Under This Policy**

Your rights and duties under this policy may not be transferred until we consent by Endorsement to the policy, except in the case of death of an individual named insured.

If you die, your rights and duties will be transferred to your legal representative but only while acting within the scope of duties as your legal representative. Until your legal representative is appointed, anyone having proper temporary custody of your property will have your rights and duties but only with respect to that property.

**20. When We Do Not Renew**

If we decide not to renew, we will mail or deliver to the first Named Insured shown in the Declarations written notice of the nonrenewal not less than 90 days before the expiration date. If notice is mailed, proof of mailing will be sufficient proof of notice.

**SECTION V – DEFINITIONS**

1. **Auto** means:
   - **a.** A land motor vehicle, trailer or semitrailer designed for travel on public roads, including any attached machinery or equipment; or
   - **b.** Any other land vehicle that is subject to a compulsory or financial responsibility law where it is licensed or principally garaged.
2. **Bodily injury** means physical injury, sickness, disease, building-related illness, mental anguish, shock or emotional distress, sustained by a person, including death resulting from any of these at any time. **Bodily injury** shall also include medical monitoring costs.
3. **Claim** means a written or verbal demand, notice or assertion of a legal right alleging liability or responsibility on the part of the insured.
4. **Clean-up costs** means reasonable costs, charges and expenses, incurred to investigate, remove, dispose of, abate, contain, treat, neutralize, monitor or test contaminated soil, surface water, groundwater, air or other media but only:
   - **a.** To the extent required by **environmental law**;
   - **b.** As respects **mold matter**, to the extent recommended in writing by an indoor environmental professional that we deem acceptable;
   - **c.** To the extent incurred by the government or any political subdivision within Definition **6.a**. **Coverage territory**; or
   - **d.** To the extent incurred by parties other than you.

   **Clean-up costs** includes **restoration costs**.
5. **Construction activities** means interior demolition, remodeling or renovation or subsurface excavation at a refinery or terminal.
6. **Coverage territory** means:
   - **a.** The United States of America (including its territories and possessions), Puerto Rico, Canada and the Gulf of Mexico; or
   - **b.** All other parts of the world if the injury or damage is caused by or results from a **pollution event**:
     - **(1)** On, at, under or migrating from a **non-owned location** or a scheduled **covered location** located in all other parts of the world;
     - **(2)** Arising out of **your work**; or
     - **(3)** During **transportation**.

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However, we assume no responsibility for furnishing certificates or evidence of insurance or bonds and we will not be liable for any fine or penalty imposed on you for failing to comply with insurance laws.

7. **Covered location** means:

   **a.** Any **location** you own, occupy, lease pursuant to terms of an oil & gas mineral lease or access pursuant to an easement or license agreement as of the effective date of the **policy period**;

   **b.** Any **location** in which you have a non-operating working interest pursuant to a Joint Operating Agreement as of the inception of the **policy period**;

   **c.** A **non-owned location**;

   **d.** A **divested location**; and

   **e.** Any **location** added by Endorsement to this policy.

8. **Crisis management costs** means reasonable costs, charges and expenses incurred for services provided by a crisis management firm that we deem acceptable. However, **crisis management costs** do not include compensation, fees, benefits, overhead charges or expenses of the insured.

9. **Divested location** means any **location** you cease to own, occupy, lease pursuant to terms of an oil and gas lease, access pursuant to an easement or license agreement or have a non-operating working interest pursuant to a Joint Operating Agreement during the **policy period** or any policy period of a policy previously issued by us to you providing coverage substantially the same as that provided by **SECTION I – COVERAGES** of this policy.

10. **Emergency costs** means reasonable costs, charges and expenses incurred to investigate, remove, dispose of, abate, contain, treat, neutralize, monitor or test contaminated soil, surface water, groundwater, air or other media.

    **Emergency costs** include **crisis management costs**.

11. **Employee** includes a **leased worker** and a **temporary worker**.

12. **Environmental damage** means physical damage to land, any **mode of transportation**, structures on land or water, the atmosphere, any watercourse or body of water including surface water or groundwater, giving rise to **clean-up costs**.

    **Environmental damage** does not include **property damage**.

13. **Environmental law** means any federal, state, provincial, municipal or local laws, including, but not limited to, statutes, rules, ordinances, guidance documents, regulations and all amendments thereto, including state voluntary cleanup or risk based corrective action guidance, and governmental, judicial or administrative orders and directives that are applicable to a **pollution event.**

14. **Executive officer** means a person holding any of the officer positions created by your charter, constitution, by-laws or any other similar governing document.

15. **Insured contract** means:

    **a.** A Joint Operating Agreement;

    **b.** A contract for a lease of premises;

    **c.** A sidetrack agreement;

    **d.** Any easement or license agreement;

    **e.** An obligation, as required by ordinance, to indemnify a municipality, except in connection with work for a municipality;

    **f.** An elevator maintenance agreement;

    **g.** That part of any other contract or agreement pertaining to your business (including an indemnification of a municipality in connection with work performed for a municipality) under which you assume the tort

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liability of another party to pay for **bodily injury**, **property damage** or **environmental damage** to a third person or organization. Tort liability means a liability that would be imposed by law in the absence of any contract or agreement.

Paragraph **g.** does not include that part of any contract or agreement that indemnifies an architect, engineer or surveyor for injury or damage arising out of:

**(1)** Preparing, approving, or failing to prepare or approve, maps, shop drawings, opinions, reports, surveys, field orders, change orders or drawings and specifications; or

**(2)** Giving directions or instructions, or failing to give them, if that is the primary cause of the injury or damage.

16. **Intrusive investigation** means the collection of original samples of soil, surface water or groundwater to analyze for quantitative values of various contaminants, performed for one or more of the following reasons:
    **a.** Contemplation of purchase or purchase by a person or entity other than you;
    **b.** Change in capital structure or ownership requiring **intrusive investigation**;
    **c.** Your noncompulsory desire to understand **environmental damage**;
    **d.** State specific Property Transfer Act requirements.
17. **Leased worker** means a person leased to you by a labor leasing firm under an agreement between you and the labor leasing firm, to perform duties related to the conduct of your business. **Leased worker** does not include a **temporary worker**.
18. **Location** means:
    **a.** Premises involving the same or connected lots;
    **b.** Premises whose connection is interrupted only by a street, roadway, waterway or right-of-way of a railroad;
    **c.** Real property contained within an easement.

    **Location** includes pooled units.
19. **Misdelivery** means the delivery of any liquid product into a wrong receptacle or to a wrong address or the erroneous delivery of one liquid product for another.
20. **Mode of transportation** means an **auto**, railcar, rolling stock, train, watercraft or aircraft. **Mode of transportation** does not include pipelines.
21. **Mold matter** means mold, mildew and fungi, whether or not such **mold matter** is living.
22. **Natural resource damage** means physical injury to or destruction of, as well as the assessment of such injury or destruction, including the resulting loss of value of land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.)), any state, local or provincial government, any foreign government, any Native American tribe, or, if such resources are subject to a trust restriction on alienation, any member of a Native American tribe.
23. **Newly acquired location** means any **location** that:
    **a.** You begin ownership or occupancy of after the effective date of the **policy period**; or
    **b.** You enter into a lease agreement pursuant to terms of an oil and gas mineral lease, an easement or license agreement or a non-operating working interest pursuant to a Joint Operating Agreement after the effective date of the **policy period**.

    However, coverage does not apply to **bodily injury**, **property damage** or **environmental damage** that occurred before you began ownership or occupancy or entered into any agreements in **b.** above.

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A **newly acquired location** does not include a **location** which is specifically scheduled as a **covered location**.

24. **Non-owned location** means any **location** performing operations or services on your behalf provided that the **location** is not, and never was, owned by, occupied by, loaned to, leased pursuant to terms of an oil and gas lease or accessed pursuant to an easement or license agreement by any insured. A **non-owned location** shall also include any job site location leased, rented, occupied or borrowed for use as a staging area to facilitate **your work**.

    **Non-owned location** does not include:

    **a.** Any **location** which any insured has or had a non-operating working interest pursuant to a Joint Operating Agreement.

    **b.** Any **location** which is not licensed by the appropriate federal, state or local authority to perform storage, disposal, processing or treatment of waste from your operations or **your work** in compliance with **environmental law**.

    **c.** Any **location** or any part thereof that has been listed or proposed to be listed on the Federal National Priorities list (NPL) or a state specific superfund site list prior to waste from your operations or **your work** being legally consigned for delivery or delivered for storage, disposal, processing or treatment at such **location**.

    **d.** Any **location** of a purchaser or user of **your product**.

25. **Nuclear material** means source material, special nuclear material or byproduct material which have the meanings given them in the Atomic Energy Act of 1954 or in any law amendatory thereof.

26. **Policy period** means the period of time stated in the Declarations. However, if the policy is cancelled in accordance with **SECTION IV – CONDITIONS**, Condition **2. Cancellation**, the **policy period** ends on the effective date of such cancellation.

27. **Pollutants** means any solid, liquid, gaseous or thermal irritant, or contaminant, including smoke, soot, vapor, fumes, acids, alkalis, chemicals, hazardous substances, hazardous materials, or waste materials, including medical, infectious and pathological wastes. **Pollutants** includes electromagnetic fields, **mold matter** and legionella pneumophila.

28. **Pollution event** means:

    **a.** The discharge, dispersal, release, escape, migration, or seepage of **pollutants** on, in, into, or upon land, any **mode of transportation**, structures on land or water, the atmosphere, any watercourse or body of water including surface water or groundwater; or

    **b.** The presence of **mold matter**; or

    **c.** **Misdelivery**.

    **Pollution event** includes the illicit abandonment of **pollutants** at any **location** which is owned or occupied by you provided that such abandonment was committed by parties other than an insured and without the knowledge of a **responsible insured**.

    **Pollution event** includes a **time-element pollution event**.

29. **Property damage** means:

    **a.** Physical injury to or destruction of tangible property, including all resulting loss of use and diminished value of that property. All such loss of use and diminished value shall be deemed to occur at the time of the physical injury that caused it;

    **b.** Loss of use and diminished value of tangible property that is not physically injured or destroyed. All such loss of use shall be deemed to occur at the time of the **occurrence** or **pollution event** that caused it; or

    **c.** **Natural resource damage**.

    **Property damage** does not include **environmental damage**.

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For the purpose of this insurance, electronic data is not tangible property. As used in this definition, electronic data means information, facts or programs stored as or on, created or used on, or transmitted to or from computer software, including systems and applications software, hard or floppy disks, CDROMS, tapes, drives, cells, data processing devices or any other media which are used with electronically controlled equipment.

30. **Recognized environmental condition** means a recognized environmental condition (REC) identified in a Phase I Environmental Site Assessment identifying the presence or likely presence of a hazardous substance or petroleum product indicative of:
    - **a.** An existing **pollution event**;
    - **b.** A past **pollution event**; or
    - **c.** A material threat of a future **pollution event**.
31. **Responsible insured** means:
    - **a.** Your **executive officers**, directors, partners or members;
    - **b.** Your manager of a **covered location** or **newly acquired location**;
    - **c.** Your **employee** responsible for environmental affairs, health and safety affairs, control or compliance or any other **employee** authorized by you to give or receive notice of a **claim**.
32. **Restoration costs** means reasonable and necessary costs incurred by the insured, to repair, restore or replace damaged real or personal property damaged during work performed in the course of incurring **clean-up costs** in order to restore the property to the condition it was in prior to being damaged during such work. **Restoration costs** shall not exceed the lesser of actual cash value of such real or personal property or the cost of repairing, restoring or replacing the damaged property with other property of like kind and quality. An adjustment for depreciation and physical condition shall be made in determining actual cash value. If a repair or replacement results in better than like kind or quality, we will not pay for the amount of the betterment, except to the extent such betterments of the damaged property entail the use of materials which are environmentally preferable to those materials which comprised the damaged property. Such environmentally preferable material must be certified as such by an applicable independent certifying body, where such certification is available, or, in the absence of such certification, based on our judgment in our sole discretion.
33. **Suit** means a civil proceeding in which damages to which this insurance applies are alleged. **Suit** includes an arbitration proceeding in which such damages are claimed and to which the insured must submit or does submit with our consent or any other alternative dispute resolution proceeding in which such damages are claimed and to which the insured submits with our consent.
34. **Temporary worker** means a person who is furnished to you to substitute for a permanent worker on leave or to meet seasonal or short-term workload conditions.
35. **Time-element pollution event** means a **pollution event** which:
    - **a.** First commences during the **policy period**;
    - **b.** Is first discovered by the insured within ten business days of commencement;
    - **c.** Is reported to us in writing within 30 business days of commencement; and
    - **d.** Does not originate or arise from an **underground storage tank**.
36. **Transportation** means the movement of goods, product, merchandise, supplies or waste in a **mode of transportation** by the insured or a third-party carrier from the time of movement from the point of origin until delivery to the final destination. **Transportation** includes the movement of goods, products, merchandise, supplies or waste into, onto or from a **mode of transportation**.
37. **Underground storage tank** means any tank, including any piping and appurtenances connected to the tank, located on or under a **covered location** or a **newly acquired location**, that has at least 10% of its combined volume underground. **Underground storage tank** does not include:

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**a.** Septic tanks, sump pumps, or oil/water separators;

**b.** A tank that is enclosed within a basement or cellar, if the tank is upon or above the surface of the floor; or

**c.** Storm-water or wastewater collection systems.

**38. Volunteer worker** means a person who is not your **employee**, and who donates his or her work and acts at the direction of and within the scope of duties determined by you, and is not paid a fee, salary or other compensation by you or anyone else for their work performed for you.

**39. Your product**:

**a.** Means:

**(1)** Any goods or products, other than real property, manufactured, sold, handled, distributed or disposed of by:

**(a)** You;

**(b)** Others trading under your name; or

**(c)** A person or organization whose business or assets you have acquired; and

**(2)** Containers (other than vehicles), materials, parts or equipment furnished in connection with such goods or products.

**b.** Includes:

**(1)** Warranties or representations made at any time with respect to the fitness, quality, durability, performance or use of **your product**; and

**(2)** The providing of or failure to provide warnings or instructions.

**40. Your work** means work or operations performed by you or on your behalf scheduled by Endorsement to this policy.



**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# CONSTRUCTION ACTIVITIES EXCLUSION DELETION

This endorsement modifies insurance provided under the following:
PRIME PUMPER POLLUTION LIABILITY COVERAGE

It is hereby agreed that the policy to which this Endorsement is attached is amended as follows:

**SECTION I – COVERAGES**, **Coverage A – Covered Location Pollution Liability**, Paragraph **2. Exclusions**, Exclusion **c. Construction Activities** is deleted in its entirety.




ALL OTHER TERMS, CONDITIONS AND EXCLUSIONS OF THIS POLICY REMAIN UNCHANGED.

**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# DESIGNATED COVERED LOCATION LIMITATION

This endorsement modifies insurance provided under the following:
PRIME PUMPER POLLUTION LIABILITY COVERAGE FORM

It is hereby agreed that the policy to which this Endorsement is attached is amended as follows:

**A. SECTION V – DEFINITIONS**, Definition **7. Covered location** is deleted and replaced with the following:

**7. Covered location** means the **location(s)** designated in the Schedule below and any **non-owned location** utilized by a **covered location** for the disposal of your waste generated and transported solely from that **covered location**.

**B. SECTION I – COVERAGES**, **Coverage B – Miscellaneous Pollution Liability**, Paragraph **1. Insuring Agreement**, Subparagraph **a.** is deleted and replaced with the following:

**a.** We will pay those sums that the insured becomes legally obligated to pay as damages, to which this insurance applies, because of:

**(1) Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** arising out of **your work** scheduled to this policy by Endorsement; or

**(2) Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** during **transportation** to or from a **covered location**.

**C. SECTION I – COVERAGES**, **Coverage C – Emergency and Crisis Management Costs**, Paragraph **1. Insuring Agreement**, Subparagraph **a.** is deleted and replaced with the following:

**a.** We will pay **emergency costs** incurred by or on behalf of the insured in response to an imminent or substantial threat to human health or the environment caused by or resulting from a **pollution event**:

**(1)** Arising out of **your work**;

**(2)** During **transportation** to or from a **covered location**; or

**(3)** On, at, under or migrating from a **covered location**.

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**SCHEDULE OF DESIGNATED COVERED LOCATION(S):**

| WELL DESCRIPTION |
| --- |
| |

**WELL DESCRIPTION**

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ALL OTHER TERMS, CONDITIONS AND EXCLUSIONS OF THIS POLICY REMAIN UNCHANGED.

**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# SUBSURFACE STORAGE OF NATURAL GAS EXCLUSION DELETION

This endorsement modifies insurance provided under the following:
PRIME PUMPER POLLUTION LIABILITY FORM

It is hereby agreed that the policy to which this Endorsement is attached is amended as follows:

**SECTION I – COMMON EXCLUSIONS**, Exclusion **9. Subsurface Storage of Natural Gas** is deleted in its entirety.

ALL OTHER TERMS, CONDITIONS AND EXCLUSIONS OF THIS POLICY REMAIN UNCHANGED.

**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# FINANCIAL RESPONSIBILITY – UNDERGROUND INJECTION CONTROL PROGRAM – CLASS VI

This endorsement modifies insurance provided under the following:
PRIME PUMPER POLLUTION LIABILITY COVERAGE FORM

It is hereby agreed that the policy to which this Endorsement is attached is amended as follows:

Solely as respects the **covered location(s)** identified in the Schedule of this Endorsement and the insured's obligation to demonstrate financial responsibility under the United States Environmental Protection Agency, Chapter I – Environmental Protection Agency, Subchapter D – Water Programs, Part 146 – Underground Injection Control Program: Criteria and Standards, Subpart H – Criteria and Standards Applicable to Class VI Wells, Section 40 CFR § 146.85, it is hereby agreed:

**SCHEDULE:**

| **Covered Location: Facility Name and Mailing Address** | **Covered Location:** | **Permit Number:** |
|---|---|---|
| | | |

**LIMITS of INSURANCE:**

| | |
|---|---|
| **Financial Responsibility Each Event Limit** | TBD |
| **Financial Responsibility Aggregate Limit** | TBD |

**A. SECTION III – LIMITS OF INSURANCE AND DEDUCTIBLE** is amended to include the following:

The Financial Responsibility Each Event Limit shown in the Schedule of this Endorsement is the most we will pay for the sum of all damages and **clean-up costs** under **SECTION I – COVERAGES, Coverage A – Covered Location Pollution Liability** because of **bodily injury, property damage** or **environmental damage** caused by or resulting from the same, related or continuous **pollution event** at a **covered location** shown in the Schedule.

The Financial Responsibility Aggregate Limit shown in the Schedule of this Endorsement is the most we will pay for the sum of all damages and **clean-up costs** under **SECTION I – COVERAGES, Covered Location Pollution Liability**, **Coverage A – Covered Location Pollution Liability**.

**B. SECTION IV – CONDITIONS** is amended to include the following:

We agree to furnish the Regional Administrator of the USEPA a signed duplicate original of the policy and all endorsements when requested.

**C. SECTION IV – CONDITIONS**, Condition **3. Cancellation** is deleted in its entirety and replaced with the following:

**2. Cancellation**

**a.** We may cancel this policy only for nonpayment of premium. In such event, we will mail or deliver to the first Named Insured and the Regional Administrator of the USEPA, by certified mail, written notice of cancellation at least 120 days before the effective date of cancellation.

**b.** We will mail or deliver our notice to the first Named Insured's last mailing address known to us.

**c.** Notice of cancellation will state the effective date of cancellation. The **policy period** will end on that date.




ALL OTHER TERMS, CONDITIONS AND EXCLUSIONS OF THIS POLICY REMAIN UNCHANGED.

**Effective Date of Endorsement:**
**Insured Name:**

THIS ENDORSEMENT CHANGES THE POLICY. PLEASE READ IT CAREFULLY.

# PRIOR KNOWN POLLUTION EVENT EXCLUSION AMENDMENT

This endorsement modifies insurance provided under the following:
PRIME PUMPER POLLUTION LIABILITY COVERAGE FORM

It is hereby agreed that the policy to which this Endorsement is attached is amended as follows:

**SECTION I – COVERAGES**, **Coverage A – Covered Location Pollution Liability**, Paragraph **2. Exclusions**, Exclusion **f. Prior Known Pollution Event** is deleted and replaced with the following:

**f. Prior Known Pollution Event**

**Bodily injury**, **property damage** or **environmental damage** caused by or resulting from a **pollution event** or a **recognized environmental condition** known to a **responsible insured** prior to **(i)** the effective date of the **policy period (ii)** the effective date of an Endorsement to this policy adding a **covered location** or **(iii)** the acquisition or initial occupancy date of a **newly acquired location**.

This exclusion does not apply if:

**(1)** The **pollution event** known to a **responsible insured** did not meet reporting requirements under **environmental law**. However, if no reporting requirements exist for such known **pollution event** then this exception does not apply;

**(2)** The presence of **mold matter** known to a **responsible insured** has been remediated to the extent recommended in writing by an indoor environmental professional that we deem acceptable;

**(3)** A No Further Action (NFA) or equivalent decision has been documented in writing in accordance with **environmental law** as respects the **pollution event** or **recognized environmental condition** giving rise to the **bodily injury**, **property damage** or **environmental damage**;

**(4)** We have been notified in writing of such **pollution event** giving rise to the **bodily injury**, **property damage** or **environmental damage** during the policy period of a policy previously issued by us to you; or

**(5)** The **pollution event** or **recognized environmental condition** giving rise to the **bodily injury**, **property damage** or **environmental damage** is identified in the Schedule below:

**SCHEDULE:**

None Scheduled

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ALL OTHER TERMS, CONDITIONS AND EXCLUSIONS OF THIS POLICY REMAIN UNCHANGED.

# CERTIFICATE OF INSURANCE

Name and Address of Insured: _____

Name and Address of Insurer: _____

Policy Amount: _____

Policy Number: _____

Effective Date: _____

Certification:

Ascot Specialty Insurance Company, the Insurer, as identified above, hereby certifies that it has issued liability insurance covering the following Injection Well(s):

| Name | Address | Identification No. |
|---|---|---|

Ascot Specialty Insurance Company, the Insurer, hereby certifies that it has issued to the Insured the policy of insurance identified above to provide financial assurance for emergency and remedial response for the injection wells identified above. The Insurer further warrants that such policy conforms in all respects with the requirements for the fulfillment of emergency and remedial response obligations as described by 40 CFR §146.94 as applicable and as such regulations were constituted on the date shown below. It is agreed that any provision of the policy inconsistent with such regulations is hereby amended to eliminate such inconsistency.

The Insurer may cancel the policy only for failure to pay the premium and by sending notice of cancellation by certified mail to the owner or operator and to the Director for the area in which the injection well is located. The EPA requires that cancellation not become final for 120 days beginning on the date of receipt of the notice of cancellation by the Director, as evidence by the return receipts.

Whenever requested by the Director, the Insurer agrees to furnish to the Director a duplicate original of the policy listed above, including all endorsements.

[Signature of an authorized representative of Insured]

[Name]

[Title], [Authorized Representative of Ascot Specialty Insurance Company]

[Address of Representative]

[Signature of Witness or Notary]

[Date]

SOMPO

May 8, 2024

Re: Tallgrass High Plains Carbon Storage, LLC- CCS Wyoming Project
Class VI Application 2023-041
Facility ID No. WYS-021-00155
Facility Name: Spirea I-1
Facility Address: NAD83 Coordiante System: 41.052367, -104.3424469

To Whom It May Concern:

It is the privilege of Endurance Assurance Corporation, Endurance American Insurance Company, Lexon Insurance Company, and Bond Safeguard Insurance Company (individually and collectively, "Sompo International"), to provide bonds on behalf of Tallgrass High Plains Carbon Storage, LLC for the CCS Wyoming Project. In our opinion, Tallgrass High Plains Carbon Storage, LLC remains properly financed, well equipped and capably managed. At their request we will give favorable consideration to providing required bonds in support of Tallgrass High Plains Carbon Storage, LLC up to $20,000,000 for the referenced facility.

Please note the decision to issue surety bonds is a matter between Tallgrass High Plains Carbon Storage, LLC and Sompo as Surety, and will be subject to our standard underwriting at the time of the final bond request, which will include but not be limited to the review and acceptability of the contract documents, bond forms and financing. We assume no liability to third parties or to you, if for any reason we do not execute said bonds.

The writing companies of Sompo are listed on the US Treasury Departement's Listing of Approved Sureties with an underwriting limitation expressed therein of over $290,000,000. The A.M. Best Company has assigned Sompo International writing companies a rating of A+ XV. Lastly, Sompo Surety is fully licensed and authorized to write bond in the State of Wyoming.

Should you have further questions, please do not hesitate to contact me.

Sincerely,

Endurance Assurance Corporation (Sompo International)

Hillary D. Shepard, Attorney-in-Fact
Lockton Companies
Assistance Vice President, Surety Account Executive

**Sompo**
12890 Lebanon Road, Mt. Juliet, TN 37122, U.S.
**T** +1 615 553 9500
**sompo-intl.com**

*4 April 2024*

# Tallgrass Energy

# Eastern Wyoming Spirea Project

## Written Financial Assurance Cost Estimates in Support of:

Section 26(b)(i)(E) Emergency and Remedial Response

Section 26(b)(ii)(A)-(G) Event-Based Risk Activities
*(Risks 1 through 7 of the Risk Activity Table in Appendix A of Chapter 24)*

**Prepared for:**

**Tallgrass Energy**

**Eastern Wyoming Spirea Project**

**Prepared by:**

**Industrial Economics, Inc.**

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## 1.0 INTRODUCTION

This report provides written Financial Assurance Cost Estimates for the Eastern Wyoming Spirea Sequestration Project located near Carpenter, Wyoming (hereinafter, the Spirea Project).[1] The estimates conform to the regulatory requirements promulgated at Wyoming Water Quality Rules (WWQR) Chapter 24: Section 26(b)(i)(E) Emergency and Remedial Response, and Section 26(b)(ii)(A)-(G) Event-Based Risk Activities (Risks 1 through 7 of the Risk Activity Table in Appendix A of Chapter 24).[2] These estimates are intended to inform the face amount of financial assurance(s) necessary to satisfy emergency and remedial response actions, and the stated event-based risk activities summarized in Appendix A of Chapter 24.[3,4] For the avoidance of doubt, this document does not include costs associated with corrective action, well plugging and abandonment, post-injection site care or site closure (including removal of above-ground facilities and site reclamation) in the estimation of ERR response costs. All such costs are addressed elsewhere in the Tallgrass Class VI permit application.

Estimating financial assurance cost estimates for possible emergency and remedial responses, as well as actions to address the event-based risk activities contemplated in Appendix A of Chapter 24 necessitates understanding of the interactions between the carbon capture and underground storage (CCUS) stream, the geophysical environment in which it will be stored, and nearby populations. The long-term nature of such projects, the low (but not zero) probability of a release event occurring that may require emergency and remedial response, variability in potential incident conditions at the site, the size of the potentially impacted population, and likely exposure pathways (among other factors) inform the following emergency and remedial response cost estimates.

As described in more detail below, we combine readily available information with the results of Monte Carlo analysis tailored to project-specific risks and uncertainties to generate reasonable upper bound estimates of financial assurance costs related to emergency and remedial response and WWQR event-based risk activities.

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[1] The Spirea Project comprises a single injection well: Spirea I-1 at latitude/longitude (NAD83): 41.052367, -104.424469. The project sponsor indicates that the Spirea Project AOR borders but does not overlap with the Tallgrass Energy Eastern Wyoming Sequestration (EWS) Hub Project. The Spirea Project financial assurance cost estimate presented in this document is 'stand-alone' and does not overlap with the separate and distinct financial assurance cost estimate developed for the Tallgrass EWS Hub Project. As such, it is possible to add the two face amounts together to arrive at a combined financial assurance coverage value across the projects.

[2] Per WWQR Chapter 24, Section 26(b)(iii) and Appendix A, Risk Activity Table, cost estimation for "Major Risk" 1 through 7, as listed in Appendix A of WWQR, can be found in the following sections of this report: Section 7.5 (Risk 1 Mineral Rights Infringement), Sections 7.1 and 7.2 (Risk 2 Water Quality Contamination), Sections 7.3 and 7.4 (Risk 3 Single Large Volume CO2 Release to Surface and Risk 4 Low Level CO2 Release to Surface), Section 7.7 (Risk 5 Storage Rights Infringement), Section 7.6 (Risk 6 Modified Surface Topography Resulting in Property/Infrastructure Damage), and Sections 7.1 and 7.2 (Risk 7 Entrained Contaminant (Non-CO2) Releases). As we understand from the project developer, Risk 8 (Accidents/Unplanned Events (Typical Insurable Events) is addressed through the company's general liability insurance coverages, and therefore are not separately quantified in this report for purposes of ERR cost estimation.

[3] Per WWQR Chapter 24, Section 26(b), financial assurance cost estimates (including those that address emergency and remedial response) must be updated annually, or within 60 days of receiving notice that the Administrator has determined that a demonstration of financial assurance is not adequate. Consistent with Section 25(a)(i) and (a)(ii) requirements, ERR cost estimates also will need to be reevaluated after any updates to the emergency and remedial response plan.

[4] In general, because "accidents and unplanned events" are typical insurable events that are covered through the company's general liability coverages, they are not addressed further in this analysis. Financial assurance cost estimates for well capping and permitted abandonment, and removal of above-ground facilities and site reclamation are addressed elsewhere in the Tallgrass submission, and therefore are not addressed further in this analysis.



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Importantly, model results will vary with factors that would be expected to impact project risk, such as: the purity of the sequestration stream and degree to which any co-contaminants might result in additional emergency response challenges; the duration of injection and post-injection site care activities; the number of wells present in the Area of Review (AOR) that extend below USDWs and the proportion that penetrate caprock; population density and the type/extent of private water well use; the presence and size of community/municipal water systems; and the use and length of new pipelines to transport captured CO2 to injection well locations. In our view, the following analyses and resulting cost estimates provide a reasonable, conservative, and objective basis for determining the face amount of financial assurance instrument(s) necessary to support a Class VI permit consistent with Wyoming regulation.

The cost estimation method applied to the Spirea Project is based on the peer-reviewed approach pioneered by Industrial Economics, Incorporated ("IEc"); this approach has been used to inform estimation of emergency and remedial response costs in previously approved Class VI permits.[5] IEc tailored the valuation parameters of its Carbon Capture and Storage stochastic Monte Carlo model ("CCSvt model") to reflect site-specific factors associated with the Spirea Project. Specifically, the model's input parameters reflect the geologic location and specific chemical composition of the project's CCUS stream, as well as site-specific conditions that exist within the established area of review. The analysis adopts several conservative input assumptions and incorporates probabilistic calculations that allow for multiple release incidents through operation and post-injection site care. Cost estimates are based upon generally accepted actions to address the types of events identified in WWQR Chapter 24 Section 26(b)(ii) and the Risk Activity Matrix identified in Section 26(b)(iii) and supported by WWQR Chapter 24 Appendix A.

Based on a model run of 50,000 Monte Carlo trials **we estimate an upper-bound financial assurance cost estimate to satisfy emergency and remedial response and WWQR event-based risk activities of $5.3 million in current 2024 dollars.** This upper-bound cost estimate reflects the single Monte Carlo trial with the greatest financial assurance costs out of the 50,000 trials run. We believe this estimate to be reasonable and appropriately conservative. In the sections that follow, we discuss the basis for our cost estimates in greater detail.

## 2.0 WWQR CHAPTER 24 SECTION 26: FINANCIAL ASSURANCE COST REQUIREMENTS

The Wyoming regulations promulgated under Chapter 24 Section 26 require demonstration of financial responsibility, and specifically that owners or operators of Class VI wells establish, demonstrate, and maintain financial responsibility for emergency and remedial response pursuant to Section 25 of the Chapter. In deriving the financial assurance cost estimate, owners and operators of Class VI wells must consider the Risk Activity Matrix in Appendix A of Chapter 24, which includes the following array of event-based risk activities:

A. Contamination of underground sources of water including, drinking water supplies;
B. Mineral rights infringement;

[5] This approach informed the ERR coverage estimates for the Class VI permits in North Dakota, including for example, Dakota Gasification Company (Case No. 29450), Red Trail Energy, LLC (Case No. 28848) and Blue Flint Sequester Company, LLC (Case No.: 29888). See Trabucchi, C., Donlan, M., Sprit, V., Friedman, S. and Esposito, R., 2014, 'Application of a Risk-Based Probabilistic Model (CCSvt Model) to Value Potential Risks Arising from Carbon Capture and Storage', Energy Procedia 63 (2014) 7608-7618, https://www.sciencedirect.com/science/article/pii/S1876610214026101. See also Trabucchi, C., Donlan, M. and Wade, S., 2010 'A Multi-Disciplinary Framework to Monetize Financial Consequences Arising from CCS Projects and Motivate Effective Financial Responsibility', International Journal of Greenhouse Gas Control 4 (2010) 388-395, https://www.sciencedirect.com/science/article/abs/pii/S1750583609001108. See also Trabucchi, C., Donlan, M., Huguenin, M, Konopka, M., Bolthrunis, S., 2012, Valuation of Potential Risks Arising from a Model, Commercial-Scale CCS Project Site: Prepared for GCCSI and the CCS Valuation Sponsor Group, June 1, 2012, https://www.globalccsinstitute.com/archive/hub/publications/40831/iec2012valuationofpotentialrisks.pdf.

C. Single large-volume release of carbon dioxide that impacts human health and safety or that causes ecological damage;
D. Low-level leakage of carbon dioxide to the surface that impacts human health and safety or that causes ecological damage;
E. Storage rights infringement;
F. Property and infrastructure damage, including changes to surface topography and structures;
G. Entrained contaminant releases of contaminants other than carbon dioxide;
H. Accidents and unplanned events;
I. Well capping and permitted abandonment; and
J. Removal of above-ground facilities and site reclamation.

This report focuses on financial assurance cost estimation for Section 26(b)(i)(E) Emergency and Remedial Response, and Section 26(b)(ii)(A)-(G) Event-Based Risk Activities – Risks 1 through 7 of the Risk Activity Table in Appendix A of Chapter 24, (hereinafter WWQR event-based risk activities). As previously noted, because "accidents and unplanned events" are typical insurable events separately covered through the company's general liability coverages, they are not addressed further in this section. The exception are accidents and unplanned events that may endanger an underground source of drinking water, or threaten human health, safety, or the environment. In addition, financial assurance cost estimates for well capping and permitted abandonment (I), and removal of above-ground facilities and site reclamation (J) are addressed elsewhere in the Tallgrass submission, and therefore are not addressed further in this report.

## 3.0 MONTE CARLO APPROACH TO FINANCIAL ASSURANCE COST ESTIMATION

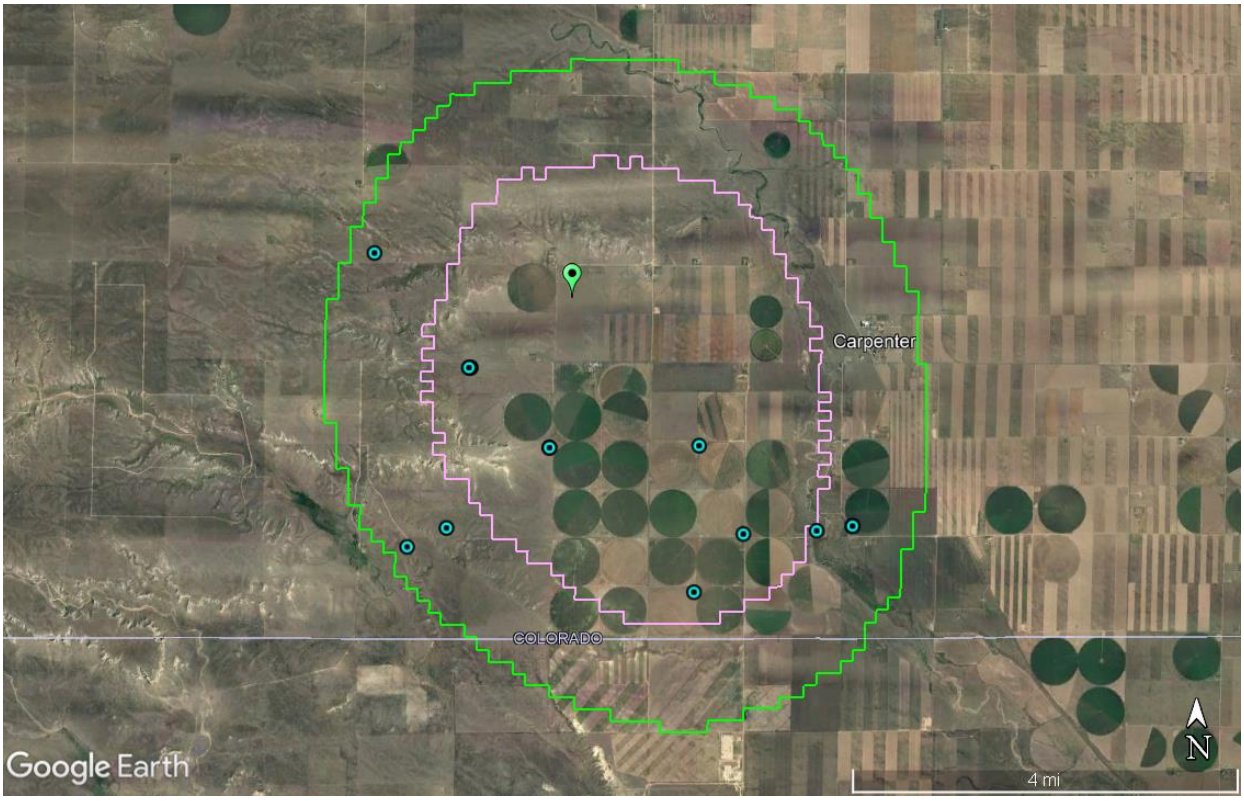
We estimate the cost of emergency and remedial response actions and WWQR event-based risk activities by tailoring the valuation parameters underpinning the CCSvt model to reflect site-specific factors associated with the Spirea Project. The CCSvt model published in the peer-reviewed technical literature leverages Monte Carlo (i.e., risk-based, probabilistic) modeling and site-specific scenario analysis (Trabucchi et al., 2014). In our view, Monte Carlo analysis is particularly well suited to the evaluation of potential costs arising from low probability events over long periods of time. As described in Trabucchi et. al (2014), key parameters which inform the CCSvt model inputs include identification of release event types and probabilities, the duration of injection and post-injection/site closure (PISC) activities, and cost distributions for anticipated response actions if ERR incidents or WWQR event-based risk activities occur.

This approach is explicitly consistent with WWQR Chapter 24 Section 26 (b)(iv) requirements, which state: "*the financial assurance cost estimate shall be based upon a multi-disciplinary analytical framework such as Monte Carlo or other commonly accepted stochastic modeling tools*." The section goes on to state that: "*cost curves shall combine risk probabilities, event outcomes, and damages assessment to calculate expected losses under a series of events;*" and, "*for all cases of potential damages, the probability distributions should be identified for 50 percent, 95 percent, and 99 percent probabilities of occurrence*." The analyses underpinning this report conform to these requirements.

## 4.0 AREA OF REVIEW

Consistent with WWQR Chapter 24 Section 26(b)(7), the information and analyses underpinning the estimation of financial assurance costs reflect the AOR for the Spirea Project, as shown in Exhibit 1 (delineated by the green line). Exhibit 1 also reflects the maximum extent of the CO2 plume, critical pressure increase, or the maximum combination of the two (shown by the purple line) and incorporates a one mile buffer (delineated by the green line). For context, Exhibit 1 also shows the location of the injection well (green tear drop) that comprise the Spirea Project, as well as oil and gas wells in the AOR (blue circles).

### Exhibit 1. Area of Review




## 5.0 DURATION OF INJECTION AND POST-INJECTION SITE CARE (PISC) ACTIVITIES

The financial assurance cost estimates reflect: (1) a 17-year CO2 injection period, (2) a 30-year PISC period, and (3) the possibility of having to address risk-based event activities that potentially could occur during the operational and PISC project phases, necessitating emergency and remedial response action. Consistent with these assumptions, the Monte Carlo calculations incorporate an overall project timeline of 47 years (i.e., 17 years of injection, plus 30 years of PISC). Financial assurance cost estimates are provided for the entirety of the project timeline, as well as by project phase.

## 6.0 RISK EVENT TYPES AND PROBABILITIES

### 6.1 Leakage through Wells, Caprock, and Faults

Exhibit 2 identifies the risk event types and probabilities used to estimate emergency and remedial response costs arising from well leaks and leakage through caprock, existing faults and induced faults. We base annual release probabilities on the Final Risk Assessment Report for the FutureGen Project Environmental Impact Statement, revised April 2007.[6] These data reflect extensive, federally-funded analysis, are publicly available, and informed the U.S. Department of Energy's development of an Analog Site Database regarding the release of CO2 from existing injection sites and natural releases.[7] The Analog Site Database includes information from four existing CCUS sites, 16 natural CO2 sites in sedimentary rock formations, and 17 sites in VHM (volcanic, hydrothermal, and metamorphic) areas. These sites have been identified in several natural analog investigations for CCUS. In addition to leakage from reservoirs via natural pathways, the FutureGen efforts considered leakage information from myriad CCUS risk assessments and developed a well failure-release event database, which reflects applied experience from the natural gas storage industry, the oil and gas industry, and wells at natural CO2 reservoirs.

[6] See https://www.energy.gov/sites/prod/files/EIS-0394-DEIS-RiskAssessmentReport-2007.pdf, p. 6-15, Table 6-11.
[7] Ibid, pg 5-1.

## Exhibit 2. Probabilities for Well, Caprock and Fault Leakage Events

| Risk Event Type | Annual Probability | Number of Wells |
|---|---|---|
| Deep Oil & Gas Well Leak | 0.1% per well[a] | 2 |
| CO2 Injection Well Leak | 0.001% per well[b] | 1 |
| Deep CO2 Monitoring Well Leak | 0.001% per well[c] | 0 |
| Rapid Leakage Through Caprock | 0.00000002%[d] | n/a |
| Slow Leakage Through Caprock | 0.004%[e] | n/a |
| Release Through Existing Faults | 0.000002%[f] | n/a |
| Release Through Induced Faults | 0.000002%[g] | n/a |
| Leakage Through Caprock/Faults then Shallow Well | 0.008%[h] | 18 |

Source for risk events and annual probabilities: Final Risk Assessment Report for the FutureGen Project Environmental Impact Statement, revised April 2007, available online at: https://www.energy.gov/sites/prod/files/EIS-0394-DEIS-RiskAssessmentReport-2007.pdf, p. 6-15, Table 6-11.

Additional Notes:

a) Highest probability within FutureGen range for undocumented deep wells developed from the FutureGen analog database.
b) Highest probability within FutureGen range for CO2 injection wells developed from the FutureGen analog database.
c) Conservatively assumed to be equal to CO2 injection well leak probability.
d) Equal to FutureGen probability for rapid leakage through caprock developed from the FutureGen analog database.
e) Equal to FutureGen probability for slow leakage through caprock developed from the FutureGen analog database.
f) Equal to FutureGen probability for release through existing faults developed from the FutureGen analog database.
g) Equal to FutureGen probability for release through induced faults developed from the FutureGen analog database.
h) Conservatively assumed to be twice as likely as the highest caprock/fault probability.

In our view, absent event data arising from recently permitted CCUS projects in North America, the FutureGen databases offer an objective, reasonable basis for determining annual probabilities.[8] Although carbon dioxide enhanced oil recovery (CO2 EOR) is a technique used to recover oil from mature fields that may no longer be productive through traditional recovery methods, to our knowledge, there are no systematic studies of real world frequencies of CO2-related emergency and remedial response events that could be used to augment the FutureGen analyses.[9]

Estimates of potential consequences for the Spirea Project are informed by the annual probability point estimates resulting from the FutureGen efforts. In some cases, FutureGen provides a range of probabilities – in such circumstances, we conservatively use the highest probability in the range. Exhibit 2 reflects the release probabilities for eight types of event-based risk activities.[10] For well-related events, the identified probabilities reflect the risk of release for a single well.

[8] Notably, since development of the FutureGen analysis, the Arthur Daniels Midland (ADM) site in Decatur, IL was granted a Class VI permit by EPA to inject CO2 into the subsurface environment for purposes of permanent carbon capture and storage. Publicly available information suggests that, over the last decade, ADM has safely and permanently stored more than 3.5 million metric tons of CO2 at its commercial CCS site in Decatur, IL. See: https://www.adm.com/en-us/standalone-pages/adm-and-carbon-capture-and-storage/. To our knowledge, none of the more recently permitted CCS projects in North America are operational and actively injecting CO2 for permanent subsurface storage. Further, off-shore analogs such as Sleipner, do not appear to offer corresponding storage characteristics and attendant risk profiles that are akin to the system contemplated by the Spirea Project. In our view, relying on such analogs do not offer a necessarily more reasonable basis for determining annual probabilities than the FutureGen databases.

[9] See for example Porse, Sean, Sarah Wade and Susan Hovorka "Can we Treat CO2 Well Blowouts like Routine Plumbing Problems? A Study of the Incidence, Impact and Perception of Loss of Well Control" Energy Procedia 63 (2104) 7149 – 7161, which notes that "There are no standard formats for reporting loss of control events at the Federal or state level; consequently, many states have varying levels of accessibility for reporting ranging from relatively organized to completely unavailable. With such a wide degree of reporting standards, it was difficult to gather the desired data" (pg. 7154).

[10] Specified risk events could occur for a variety of reasons, including but not limited to mechanical failure, industrial activities unrelated to CCUS, incomplete/inaccurate subsurface characterization, natural or induced seismicity, other natural subsurface processes. Every WWQR event-based risk activity that occurs in the Monte Carlo analysis, whatever its underlying cause, is assumed to require an emergency and remedial response action.

As previously noted, one injection well is planned for the Spirea Project (see Exhibit 1). As noted elsewhere in the permit application, Tallgrass has determined that there are no 'deep' (i.e., deep enough to penetrate the injection zone) oil & gas wells in the AOR. However, for purposes of the Monte Carlo calculation, we conservatively assume the presence of two undocumented 'deep' oil & gas wells in the AOR. We believe that doing so provides a buffer against the possibility that records may be incomplete, and construction or natural landscape features may obscure old well locations.[11]

The project sponsor has identified 15 'shallow' (i.e., not deep enough to penetrate the injection zone) oil & gas wells in the AOR. Our Monte Carlo calculations conservatively assume the presence of two additional undocumented shallow wells.[12] We add these wells for the same reasons discussed above – a buffer against the possibility of incomplete records – resulting in a total of 17 shallow oil & gas wells for purposes of estimating consequences arising from WWQR event-based risk activities. Finally, we include the anticipated above-zone monitoring well planned for the project in the 'shallow well' category, yielding a total shallow well count of 18.

The FutureGen efforts do not provide release probability estimates for 'shallow' wells, as defined and identified for purposes of the Monte Carlo calculation. As such, we assume that shallow wells that do not penetrate the caprock have a release probability equal to twice the highest probability for caprock or fault release events. This assumption reflects the fact that CO2 or brine would need to escape through the caprock or fault before reaching the shallow well, at which point the well may yield a more direct pathway to a USDW. We believe this approach is reasonable and conservative.

The project sponsor indicates that currently no in-zone monitoring wells are anticipated. For completeness, we note that the Monte Carlo model can incorporate deep CO2 monitoring wells. FutureGen does not specifically address release probabilities for deep CO2 monitoring wells. As such, we conservatively assign an annual release probability to these wells equal to the CO2 injection wells – monitoring wells are not subject to the same type or extent of use, and therefore are likely to evince a smaller annual release probability than that assumed for purposes of this cost estimation exercise.

Because in-zone monitoring wells necessarily penetrate caprock and confining layers and extend to the surface, they represent potential conduits for CO2 injectate and/or formation brines. For completeness, the Monte Carlo model used to monetize consequences necessitating emergency and remedial response actions can incorporate deep CO2 monitoring wells for purposes of ERR cost estimation. To do so, we conservatively assign an annual release probability to in-zone monitoring wells equal to that used for CO2 injection wells. This approach is likely to realize a conservative output given that monitoring wells are not subject to the same type or extent of use as injection wells. Importantly however, as we understand, no in-zone monitoring wells are anticipated for the Spirea Project. As such, although the capability to evaluate and model the consequences of this potential risk conduit exists, we have not done so because such wells are not anticipated by the project sponsor.

[11] This adjustment for unknown wells is based on professional judgement, informed by the fact that Tallgrass has identified approximately 15 oil & gas wells in the AOR, none of which extend to depths sufficient to penetrate the injection zone.
[12] This adjustment for unknown wells is based on professional judgement, reflecting an approximately 10% increase relative to the number of known wells.

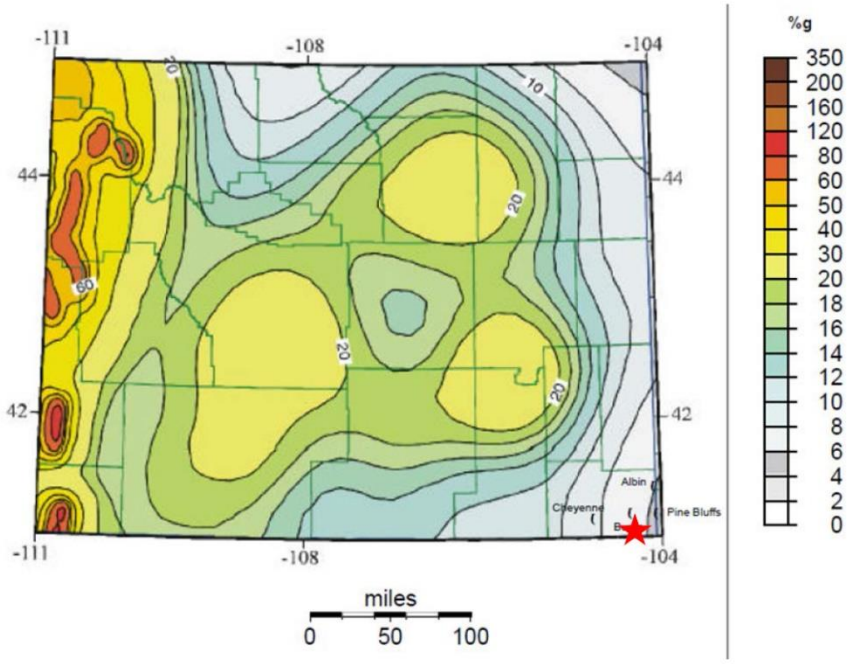
## 6.2 Pipeline Releases

The Monte Carlo calculations underpinning this cost estimation exercise include potential costs associated with the new, 'feeder' CO2 pipeline(s) that will connect the existing Trailblazer pipeline to the Spirea Project CO2 injection well.[13] The annual pipeline release probability used in the model is based on U.S. Department of Energy Pipeline and Hazardous Materials Safety Administration (PHMSA) data for CO2 pipeline release incidents. PHMSA has compiled pipeline incident data since 2002. In 2020, there were approximately 5,100 miles of CO2-carrying pipeline in the U.S., up from about 3,400 miles in 2004. There were 103 CO2 pipeline accidents recorded from 2002 through 2021. Those figures result in an annual release probability of 0.12% per pipeline mile. It is our understanding that approximately 8.5 miles of new CO2 pipeline currently are anticipated for the Spirea Project. The added feeder pipeline is to allow for transport of the CCUS stream from the existing Trailblazer pipeline to the injection well location. A reasonably conservative 1.02% annual pipeline release probability is used in this analysis.[14]

## 6.3 Induced Seismicity

We have been unable to identify any record of induced seismic events in the Spirea Project area. The project sponsor conducted an evaluation of seismic activity for Laramie County, which indicates that the project is in an area of low seismic activity. Exhibit 3 shows that the project (represented by the red star) is located in the 2% probability of exceedance in 50 years (grey zone) with a range from 5% to almost 14% peak ground acceleration in southeastern and northwestern Laramie County, respectively. As described in more detail in Section 7.6 of this document, this level of peak ground acceleration (5% to 14%) is the minimum scale of seismic event anticipated to cause measurable damage to surface infrastructure.

**Exhibit 3. USGS 2,500-year Probabilistic Acceleration Map of Wyoming***




*Map contours represent a 2% probability of exceedance in 50 years.

[13] Potential release events associated with the existing Trailblazer pipeline are subject to regulatory, permitting, and financial assurance coverage requirements separate and distinct from this Class VI permit application. As such, risk events associated with the main Trailblazer pipeline are excluded from further analysis in this report.

[14] 1.02% Spirea Project pipeline annual release probability = 0.12% release probability per CO2 pipeline mile * approximately 8.5 miles of new pipeline.

Induced seismicity of sufficient magnitude to potentially damage infrastructure most commonly occurs in areas with a history of extensive deep injection of fluids from nearby oil and gas operations.[15] As described throughout this document, the project AOR has a limited history of oil and gas development. Regardless, for financial assurance cost estimation purposes, we conservatively assume a probability and magnitude of induced seismic events equal to that for 'natural' seismic events. A 2% probability of exceedance in 50 years translates to an annual exceedance probability of 0.04%.[16]

### 6.4 Pore Space Trespass

As described elsewhere in the Tallgrass Class VI permit application materials, the project sponsor has made substantial progress obtaining pore space rights. Through the pore space unitization process, the sponsor anticipates that it will have acquired pore space rights for all subsurface areas in which injected CO2 from the injection well is expected to reside.

Based on extensive subsurface data collection, site characterization, and plume modeling efforts, the sponsor believes it is unlikely that stored CO2 will migrate to other subsurface locations. The actual movement of CO2 in the subsurface environment will be calibrated with modeled predictions on a regular and systematic basis, and therefore it is likely that any potential trespass issue would be identified prior to occurrence and the amount and/or location of ongoing CO2 injection potentially adjusted to reduce or eliminate the trespass concern. Nevertheless, for purposes of deriving a financial assurance cost estimate, we conservatively assume a 10 percent chance that trespass occurs at some point during injection and/or PISC periods, and that such trespass will necessitate a response action.[17] Specifically, the project sponsor's site characterization efforts indicate a substantially low likelihood of trespass. To ensure that the likelihood of trespass remains low, the sponsor anticipates closely monitoring the storage plumes as injection occurs; and, to the extent necessary, will adjust injection volumes and/or rates of injection if any risk of trespass emerges. Finally, after injection ends, current site characterization analyses suggest that pressure gradients will quickly dissipate, limiting the potential for plume movement and trespass during the PISC period. Regardless, for the avoidance of doubt, and in the interest of deriving a conservative estimate for purposes of ERR financial assurance coverages, we apply a 10% likelihood of trespass occurrence based on professional judgment.

## 7.0 COST DISTRIBUTIONS APPLIED TO EVENT-BASED RISK ACTIVITIES NECESSITATING EMERGENCY AND REMEDIAL RESPONSE ACTION

Previously peer-reviewed, published applications of the CCSvt model relied on 10,000 Monte Carlo trials. In the interest of reasonable conservatism, and for purposes of demonstrating financial responsibility in support of the Class VI permitting process, this analysis relies on 50,000 Monte Carlo trials. In our view, the reliance on 50,000 Monte Carlo trials offers an additional measure of conservatism and certainty. If a release from a WWQR event-based risk activity occurs during a Monte Carlo trial, the model randomly chooses a cost amount from the indicated cost distributions.

### 7.1 Well Repair Cost Distribution

Injection Well, Deep Monitoring Well, and Non-Project Deep Well repair cost distribution is as follows:

- Minimum: $5,000
- 10th percentile: $25,000

[15] See, for example, Rubinstein, Justin and Alireza Babaie Mahani. Myths and Facts on Wastewater Injection, Hydraulic Fracturing, Enhanced Oil Recovery and Induced Seismicity. Seismological Research Letters. July 2015.
[16] 0.04% annual seismic probability = 2% seismic probability over 50 years / 50 years.
[17] The Tallgrass EWS Hub Project AOR borders the Spirea Project AOR. If the EWS Hub Project Class VI permit is approved, that will add an additional element of conservatism to the Spirea financial assurance cost estimate presented in this document, because trespass east of the Spirea AOR will not be possible given that Tallgrass already hold those pore space rights.

- Median: $62,000
- 90th percentile: $140,000
- Maximum: $1,700,000
- Burr Distribution[18]

Shallow Well repair cost distribution is as follows:

- Minimum: $5,000
- 10th percentile: $8,100
- Median: $56,000
- 90th percentile: $170,000
- Maximum: $500,000
- Exponential Distribution

We apply the above cost distributions to all well release incidents that occur in the Monte Carlo trials to stop leaks and prevent reoccurrence. For the Spirea Project analysis, we conservatively assume that addressing a well-related release of CO2 would involve plugging and surface reclamation.[19] As a proxy for such costs, we rely on information and analysis provided in Raimi et al (2021).[20] This peer-reviewed, publicly available analysis provides cost estimates for plugging and surface reclamation of oil and gas wells, based on data from five states (Montana, New Mexico, Kansas, Texas and Pennsylvania). [21]

For 'deep' wells (extending more than 4,000 feet below the surface), we use a Burr distribution in which the 10th percentile, median, and 90th percentile costs align with those found for high cost (and generally deepest) wells in Raimi et al., (2021). We conservatively set the minimum cost to $5,000, notwithstanding the fact that costs below this amount were observed in the data set. We set the maximum cost to $1.7 million, consistent with the highest cost for well plugging and surface reclamation costs observed in the Raimi data set. For shallow wells (extending up to 4,000 feet below the surface) we assume an exponential distribution based on Raimi et al., (2021) data for all wells, but with a maximum cost of $500,000 (which reflects the highest cost for wells with depths up to approximately 4,000 feet.)

We believe that these estimates reasonably characterize the distribution of potential shallow and deep well repair costs in the event well-related release events were to occur at the Spirea Project.

### 7.2 Cost Distribution for USDW Non-Endangerment

- Minimum: $50,000
- Maximum: $1,475,000
- Uniform distribution

We apply the above cost distribution to all incidents that involve a well, caprock or fault release that occurs in a Monte Carlo trial. This distribution reflects several different response components, including the

[18] The Burr distribution is commonly used to fit non-normally distributed data characterized by a right-skewed distribution (i.e., most values are clustered around the left tail of the distribution while the right tail of the distribution is longer).
[19] Plugging and surface reclamation are the most likely response measures to address a release from any inactive wells in the AOR. If an active CO2 injection well, monitoring well or industrial well was the source of a release, we assume that funds described in this section would be used to support well repair.
[20] Raimi, Daniel, A. Krupnik, J-S Shah, A. Thompson. "Decommissioning Orphaned and Abandoned Oil and Gas Wells: New Estimate and Cost Drivers. Environ. Sci. Technol. 2021, 55, 10224-10230.
[21] To our knowledge, there is no systematic, detailed information repository on well repair costs specific to Wyoming. In the absence of such data, we rely on the entire Raimi et al., data set so as to ensure robust, conservative cost estimation. We explored available cost data associated with orphan wells plugged by the Wyoming Oil and Gas Conservation Commission orphan well program; these Wyoming-specific data reveal cost curves that are substantially lower than the cost distribution curve obtained when using the entire Raimi et al., data set. In the interest of conservatism, we elect to rely on the full Raimi et al., data set. See also: https://drive.google.com/file/d/19dlfOmzhCvjTxLcdWXOoHdg39x24EOqf/view.

characteristic use of USDWs in the AOR for the Spirea Project and the professional judgement of experts versed in federal and state response action to groundwater contamination incidents. We describe the underlying basis for this cost distribution below.

For groundwater that is intended for domestic use, Wyoming state groundwater regulations incorporate federal groundwater quality standards established by EPA.[22] The National Primary Drinking Water Regulations (NPDWRs) developed by EPA establish mandatory water quality standards for drinking water contaminants. These standards are referred to as "maximum contaminant levels" (MCLs), which are intended to protect the public against consumption of drinking water contaminants that present a risk to human health. An MCL is the maximum allowable amount of a contaminant in drinking water delivered to the consumer.

National Secondary Drinking Water Regulations (NSDWRs) set non-mandatory water quality standards for 15 contaminants. These standards (referred to as "secondary MCLs or SMCLs") are offered as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor. These contaminants are not considered to present a risk to human health at the SMCL.[23]

Consistent with these mandates, we evaluate potential consequences arising from release incidents or WWQR event-based risk activities at the project site, which could result in an exceedance of one or more MCLs in a USDW. We do so because, however unlikely, it is possible that such incidents could result in the need for an emergency and remedial response action. Our evaluation of potential consequences begins with the composition of the CCUS stream and the potential pathways for harm to USDWs.

- Composition of the CCUS Stream. Tallgrass anticipates that the CO2 injectate will meet the minimum pipeline specifications identified in Exhibit 4; and, the sponsor intends to operate the Spirea Project in compliance with WWQR water quality standards.[24] However, for some constituents, the pipeline specification limits in Exhibit 1 do not provide enough information to assess the potential for an MCL exceedance. For example, 'hydrocarbons' may contain various polycyclic aromatic hydrocarbons (PAHs), for which there are established MCLs. Therefore, it is possible that such contaminants could impair groundwater uses designated by the state. To address these uncertainties, as well as the possibility for trace amounts of contaminants other than those identified in Exhibit 1, the cost distributions (discussed in later sections of this document) assume use of reverse osmosis (RO) treatment units for residences potentially affected by a release event. RO treatment units are highly effective at removing a wide variety of contaminants, including PAHs.[25]

- Potential Pathways for Endangerment of USDWs. In addition to 'direct' impacts resulting from a release of constituents present in the CCUS stream into a USDW, 'indirect' impacts could arise if released CO2 reduces the USDW's pH sufficiently to increase the leaching of heavy metals from aquifer minerals at concentrations that exceed an MCL. It also is possible that increases in subsurface pressure arising from injection activities could result in USDW impacts due to resulting movement of underground brines. This analysis incorporates emergency and remedial response actions to address potential MCL exceedances that could arise in these scenarios. We anticipate that these actions also

[22] See WWQR Chapter 8, Section 4(d)(v)(A).
[23] See https://www.epa.gov/sdwa/secondary-drinking-water-standards-guidance-nuisance-chemicals.
[24] WWQR Chapter 8 cites to Federal regulatory standards (see Chapter 8 Section 4(d)(v)). Further, the Chapter also states that any release to underground water must not impair designated use(s) for particular aquifers.
[25] For example, as noted on EPA's website "RO and NF [nanofiltration] are useful for the removal a wide range of contaminants. RO can remove contaminants including many inorganics, dissolved solids, radionuclides and synthetic organic chemicals. RO can also be used for removing salts from brackish water or sea water." https://www.epa.gov/sdwa/overview-drinking-water-treatment-technologies#RO

would address any aesthetic impacts (e.g., taste, color, odor, etc.) that could be associated with potential exceedance of secondary MCLs (e.g., for pH, TDS, chlorides, etc.).[26]

**Exhibit 4. Spirea Project CO2 Pipeline Specifications**

| Constituent | Limit | Note |
|---|---|---|
| $CO_2$ | ≥ 95 mol% | |
| CO | ≤ 0.4 mol% | |
| $H_2$ | ≤ 0.5 mol% | |
| $N_2$ | ≤ 4 mol% | |
| $H_2S$ | ≤ 20 ppm | |
| Total Sulfur | ≤ 35 ppm | |
| Total NOx | ≤ 10 ppm | |
| $O_2$ | ≤ 1 mol% | |
| H2O | ≤ 150 ppm | |
| Hydrocarbons (Maximum cricondentherm dew point of hydrocarbon mix -20°F) | ≤ 4 mol % | |
| Glycol | 0.3 gallons/MMCF | |
| Maximum dew point at 400 psig | 30°F | |
| Non condensable gases | ≤ 5 mol% | Sum of $N_2$, $H_2$, $CH_4$, $O_2$, CO, Ar |

*Impurities Deleterious to Pipeline, Equipment, Downstream Systems or Reservoirs: in addition to compositional limits listed above, product shall not contain impurities deleterious to pipeline, equipment, downstream systems, or reservoirs. Impurities not listed here should be brought to the attention of $TPCO_2$ for further evaluation. Carbon dioxide delivered by anthropogenic or biogenic source that does not meet the specifications will be rejected at $TPCO_2$'s sole discretion.

Exhibit 1 provides context regarding land use within the Spirea Project AOR. As illustrated in the image, land use in the approximately 34 square mile AOR is highly rural, with a low density of scattered residences and a substantial amount of agriculture and ranching/livestock activity. There are no municipal water systems, and one population center within the AOR (Carpenter). Data provided by the project sponsor indicate that there are approximately 175 water wells distributed throughout the AOR (approximately 88 for domestic use, 68 for livestock watering (some dual-purpose domestic/livestock), and 56 for irrigation). The maximum water well depth is 520 feet. The deepest domestic well is 520 feet.

Based on the aforementioned site context, we estimate a maximum per-incident cost range tailored to the Spirea Project as follows:

- A maximum of $55,000[27] to drill new water monitoring wells, to facilitate data collection to evaluate the spatial extent, existence, and/or significance of a potential release-related plume for existing water users,[28] plus;

[26] Information provided by the project sponsor confirms that there are no USDWs (i.e., <10,000 mg/l total dissolved solids) below the storage zone, and therefore no threat of USDW endangerment from releases that might occur (however unlikely) through the bottom seal. Further, were any releases to occur at the Spirea site that could impact mineral rights, human health, ecological health, storage rights or property and infrastructure, such releases would need to penetrate and migrate through the upper confining layer of the storage zone and not through the bottom seal.

[27] $55,000 = 4 wells * 550 foot depth * $25 drilling cost per foot.
[28] At an estimated drilling cost of $25 per foot (see https://homeguide.com/costs/well-drilling-cost#cost, which estimates a cost of $15-$25 per foot for drilling a water well), this cost allowance would allow, for example, drilling of four new wells at a 550-foot depth.

- A maximum of $20,000[29] for quarterly sampling and analysis for standard field measurements and heavy metals at an estimated $200 per sample,[30] including collection and analysis, for up to two years and 12 residences,[31] plus;
- A maximum of $5,100[32] for residential replacement water for one year for up to 12 residences,[33] plus;
- A maximum of $46,200 for residential replacement water for the entire town of Carpenter for up to two years in the case of an accident in the town of Carpenter,[34] plus:
- A maximum of $30,000[35] for purchase and installation of residential reverse osmosis (RO) units at up to 12 residences,[36] plus;
- A maximum of $18,000[37] for RO replacement filters, including servicing of such units at $300 per unit per year for up to five years at 12 residences,[38] plus;
- A maximum of $400,000 for irrigation support,[39] plus;
- A maximum of $400,000 for ranch/livestock support,[40] plus:

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[29] $20,000 (rounded) = 12 residences * 8 quarterly samples * $200 per sample.

[30] See for example information from laboratory vendor Chemtech international at https://chemtech-us.com/articles/cost-of-well-water-testing-in-2021/#:~:text=It%20costs%20%24165%20at%20the,%24279%20at%20the%20full%20price, which states "the Essential Water Test is a standard test that screens the general water chemistry, the hardness and alkalinity of the water, toxic and heavy metals, nitrates and nitrites, coliform and E.coli bacteria, and silica. It costs $165 at the full price." We round up to $200 to account for potential sample collection costs.

[31] If there is a release incident, a common response measure would be to periodically test water wells within the potential impact area to determine if any residences are at risk of exposure to contaminants at levels above an MCL. If no impacts are found within two years of an incident, we anticipate that continued testing would no longer be necessary. Alternatively, if household treatment needs arose, we anticipate that treatment solutions would be implemented within two years of the incident. As a result, testing of residential wells should be unnecessary after two years.

[32] $5,100 (rounded) = 12 residences * $35 per month for 25 gallons * 12 months.

[33] If residential water well testing identifies contaminant levels of concern, replacement water for drinking and cooking would be provided for affected residents. Commercial companies offer water delivery service at approximately $35 per month for 25 gallons, a typical consumption level for a family of 3-4 (see for example pricing and family water quantity recommendations from water vendor Culligan at https://www.culligan.com/bottled-delivery/select). This pricing estimate is conservative, as it is likely that bottled water could be provided in bulk at costs lower than those charged by residential delivery services. We also note that replacement water typically is a temporary measure; in this case, if contamination issues persist for longer than one year, we anticipate that the replacement water program would end and be replaced by installation of residential reverse osmosis units to provide clean water, which is a more expensive, but more appropriate solution for longer term contamination issues.

[34] $46,200 = 55 households * $35 per month for 25 gallons * 24 months (Number of households in Carpenter from: https://censusreporter.org/profiles/16000US5612860-carpenter-wy/).

[35] $30,000 = 12 residences * $2,500 per RO unit.

[36] While some residential RO units (and other types of residential treatment technologies) can cost several hundreds of dollars, for this analysis, we assume installation of the much more expensive Kinetico K5 Drinking Water Station RO unit, which is an RO model currently designated for use in response to a severe, long-term groundwater contamination incident in North Carolina, affecting thousands of residences (see https://edocs.deq.nc.gov/WasteManagement/DocView.aspx?id=1636579&dbid=0&repo=WasteManagement). Pricing information from Consumer Reports indicates that $2,500 is a reasonable cost estimate for this unit.

[37] $18,000 = 12 residences * $300 per RO unit per year * 5 years.

[38] Annual RO unit maintenance costs will vary depending on water use, contaminant levels and other factors. Based on warranty information, replacement filter prices and professional judgement, $300 per year per unit is a reasonable approximation of annual maintenance costs. For reasons described throughout this document, we anticipate that release incidents that occur should be resolvable within months or a few years. Out of an abundance of caution, for purposes of cost estimation, we assume maintenance of RO units for five years after installation to allow for natural dilution/dissipation of any residual CO2/low pH/brine plume, supplemented by active remediation, if needed.

[39] Information provided by the project sponsor indicates that there are approximately 56 irrigation wells within the approximately 34 square mile AOR. While difficult to forecast specific irrigation needs in response to a potential release event due to seasonal timing, weather, specific crop requirements, and other factors, $400,000 provides a significant incident-specific sum that could be used for a variety of potential response activities, including but not limited to: funding new irrigation system connections to existing, unaffected wells; digging new wells in areas away from potential release impacts and connecting them to irrigation systems; farm-specific treatment solutions; and temporary replacement water (trucked water can cost about $30-$65 per 1,000 gallons).

[40] Information provided by the project sponsor indicates that there are approximately 68 water wells within the approximately 34 square mile AOR identified as serving 'stock watering' purposes (although many also co-list 'domestic' water provision). $400,000 is a

- A maximum of $500,000 for additional response and remedial actions.[41]

Summing the maximum dollar amount for each of these components results in a total maximum per-release cost of $1,475,000 (rounded), in 2024 dollars.

The maximum per-release cost reflects a cost distribution for USDW non-endangerment that is tailored to the specific circumstances of the Spirea Project. We rely on a minimum cost of $50,000 for the cost distribution, reflecting the potential for small releases insufficient to cause measurable adverse impacts, or for releases that cause minor impacts, which are easily addressed at minimal cost. For estimation purposes, we assume a uniform probability distribution in the Monte Carlo trials. That is, every incident that occurs in a trial is randomly assigned a cost from the cost distribution discussed above; and every cost within that range has an equal chance of being assigned. We offer additional context for our approach below.

Evaluation of the Spirea Project suggests that the most likely pathway for a potential release that could impact a USDW in the project's AOR is migration through a well of some kind. Such releases are associated with a very specific release location; and, tend to offer a better opportunity to identify and mitigate impacts than often is available at groundwater contamination sites caused by spatially dispersed, slow infiltration of contaminants from the surface.

As previously noted, the composition of the Spirea Project's CCUS stream has a very low potential for introducing co-constituents that could directly contaminate a USDW and cause an exceedance of a health-based MCL. Rather, potential impacts from a release more likely would occur indirectly by: 1) lowering groundwater pH, which, in turn, could lead to increased dissolution of metals present in the aquifer matrix (if present in sufficient quantities); or 2) injection-related increases in subsurface pressure that results in the vertical migration of underground brines into a USDW.

Importantly, there are natural factors that are likely to limit the impact of any released $CO_2$ on pH at the Spirea Project site. Specifically, carbonate will act to buffer pH from changes due to $CO_2$ – with a carbonate concentration of even 1% by weight, pH changes are unlikely to be meaningful. Although carbonate aquifer matrix measurements in or near the AOR were not available, information provided by the project sponsor indicates that the primary injection zone is in the Lyons formation, which in some locations includes

substantial sum that could, for example, allow for drilling one or more new wells in areas away from potential release impacts and connecting them to existing water delivery systems; facilitating more complex treatment solutions; enabling dilution with other unimpacted water sources; or providing temporary bulk replacement water (trucked water typically can cost about $30-$65 per 1,000 gallons). While water needs for livestock will depend on the season, type and age and other livestock characteristics, as an approximation we note that beef cattle can require 4-20 gallons of water per day, per head (see https://www.ag.ndsu.edu/publications/livestock/livestock-water-requirements). As additional context, if livestock required 10 gallons per day per head, and replacement water could be obtained for $65 per 1,000 gallons, that implies an annual replacement water cost on the order of roughly $250 per head per year.

[41] As part of the emergency and remedial response to a release incident involving a WWQR event-based risk activity, additional actions might be needed to protect USDWs, including limiting plume movement, accelerating dilution of CO2 concentrations or brine, extracting CO2 or brine-related contamination through air stripping or other technologies, buffering pH or constructing reactive barriers to limit CO2 impacts, reducing subsurface pressure by halting CO2 and/or other subsurface injection activities in relevant areas, and/or otherwise undertaking actions to speed the return of an impacted USDW to baseline conditions. This cost estimate reflects several factors: as discussed elsewhere in this document, CO2 releases or pressure-related brine movement through faulty wells is the most likely release pathway and can be relatively straightforward to stop through well repair/plugging; the aquifer matrix is likely to have meaningful buffering capacity that limit pH changes; resultant/residual plumes of groundwater with substantially reduced pH are not likely to be large or long-lived; dilution/natural attenuation can reduce CO2 and/or brine levels without intervention; CO2 is relatively inexpensive to remove from groundwater; low pH also is relatively inexpensive to address; subsurface pressure fronts can dissipate relatively quickly after the cessation of injection activities if lateral plume movement in the injection zone is not confined; "thief" zones between the injection formation and USDW can absorb CO2 or brine flux; density differences due to temperature and salinity can limit the vertical migration of displaced brine; and rural land use patterns and the low density of water wells in the AOI limit the potential for plume impacts on water users.

carbonates. There is one groundwater alkalinity[42] measurement in the vicinity of the AOR and it exceeds 200 mg/L, which suggests some potential for buffering capacity.

For USDW endangerment to occur from a CO2 release event that lowers aquifer pH, there also needs to be a sufficient reservoir of metals in the aquifer matrix to be leached into USDWs to result in health-based MCL exceedances. According to the project sponsor, concentrations of metals in the aquifer matrix in the AOI are not known.

With respect to potential pressure-induced brine migration into a USDW, halting or modifying injection activity until corrective action is taken (e.g., plugging/repairing a deep well that allowed brine to migrate to a USDW) can reduce subsurface pressure and limit the spatial extent/duration of potential impact. After injection is complete at the site the pressure front will dissipate over time, which also can limit the potential for USDW endangerment during the PISC period. Articles from the peer-reviewed technical literature identify additional factors that can limit potential impacts from brine migration. For example, Nicot et al., (2009) note that "owing simply to density differences due to temperature and salinity subsurface variations, a wellbore with a continuous open pathway between the injection formation and the bottom of the USDW will not necessarily lead to [brine] contamination of the USDW when CO2 is injected."[43] Nicot et al., also note that Minkoff et al., (2007) and Chang et al., (2008) showed that "thief" zone(s) between the USDW and injection formation "can attenuate significantly well bore pressure and absorb a significant fraction of the material flux."[44]

These factors support the reasonable assumption that, if a plume occurred in a USDW as a result of a release incident, that plume likely would be relatively modest in size. For example, analyses in relevant published literature generally describe radial $CO_2$ plume distances on the order of hundreds of meters or less.[45] Nevertheless, to estimate potential residential and irrigation impacts from a release incident associated with the Spirea Project, we conservatively assume that an impact plume could extend up to one mile from the release point and potentially endanger the aquifers currently used by local residents.

Specifically, an impact plume with a radius on the order of one mile from its center would affect an area roughly 3.14 square miles in size.[46] With respect to the potential number of residences that might be affected if a release event of that size were to occur in the Spirea Project AOR, our evaluation assumes impacts to a maximum of 12 households. As previously noted, satellite imagery (see Exhibit 1) shows that most of the AOR is highly rural, with a low density of scattered residences and a substantial amount of agriculture and ranching/livestock activity. As previously noted the AOR is approximately 34 square miles in size and includes approximately 88 domestic water wells, which implies an average density of about 2.6 domestic wells per square mile or about 8.1 domestic wells within a hypothetical release incident impact radius of 3.14 square miles.[47] Overall, publicly available information suggests an average residential density within the AOR that is well below the 12 residences per 3.14 square miles conservatively used in this analysis.

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[42] Alkalinity is a different measure of the capacity of water (or any solution) to neutralize or "buffer" acids.

[43] See Nicot, Jean-Philippe, Curtis M. Oldenburg, Steven L. Bryant and Susan D. Hovorka "Pressure perturbations from geologic carbon sequestration: Area of-review boundaries and borehole leakage driving forces" in Energy Procedia 1 (2009) 47-54.

[44] As cited in Nicot et al., (2009): S. E Minkoff,. S. L. Bryant, J.-P. Nicot, and C. M. Oldenburg, Modeling leakage of CO2 along a fault for risk assessment (abs.), in Sixth Annual Conference on Carbon Capture & Sequestration: Expediting deployment of industrial scale systems: Can it be done? How? Concerns to be addressed, May 7–10, Pittsburgh, Abstract #053, (2007) and K.W Chang, S. E. Minkoff and S. L. Bryant, Modeling Leakage through Faults of CO2 Stored in an Aquifer, SPE 115929, presented at 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.

[45] See for example Elizabeth Keating, D. Bacon, S. Carroll, K. Mansoor, Y. Sun, L Zheng, D. Harp and Z. Dai. Applicability of aquifer impact models to support decisions at CO2 sequestration sites. International Journal of Greenhouse Gas Control 52 (2016) 319-330. and Nicholas Huerta, D. Bacon, C. Carman and C. Brown. NRAP Toolkit Screening for CarbonSAFE Illinois – Macon County. Illinois State Geological Survey Prairie Research Institute and Pacific Northwest National Laboratory. Report prepared for US DOE 00029381. 2020.

[46] 3.14 square miles = $\pi$ * (1 mile radius)$^2$ = 3.14 * 1 square mile.

[47] 8.1 wells (rounded) = (88 domestic water wells / 34 square mile AOI) * 3.14 square mile hypothetical contamination impact area with a radius of 1 mile from its center.

## 7.3 Cost Distribution for Endangerment to Human Health from Acute or Chronic Surface Release of CO2 Injectate

- Minimum: $0
- Median: $200,000
- 75th Percentile: 400,000
- Maximum: $1,800,000
- Bimodal distribution

We apply the above cost distribution to all incidents that involve a well, caprock, fault or pipeline release that occurs in a Monte Carlo trial.

There is a non-zero possibility that WWQR event-based risk activities may result in release incidents. Such incidents can create acute or chronic exposures to nearby residents necessitating emergency and remedial response. The maximum end of the cost distribution is based on the CO2 pipeline incident that occurred in Satartia, Mississippi in 2020.[48] It is generally accepted that this incident resulted in the most significant CO2-related public health impact to date.[49]

The Satartia MS incident resulted in 45 hospitalizations. National Institute of Health (NIH) data suggests a 12-month treatment cost for 'unintentional suffocation or poisoning' at approximately $10,000 per person.[50] We believe that this estimate is reasonably conservative, and use it as the basis for the upper-bound (maximum) of the cost distribution. Importantly, the Satartia MS impacts occurred, in part, because a CO2 pipeline was located close to a small town. The town of Carpenter is located within the AOR of the Spirea Project, and has about twice the population of Satartia MS.[51] Because of Carpenter's relative size, we base the maximum health cost on an assumption of 90 hospitalizations (twice the number that occurred as a result of the Satartia incident).

In addition to treatment costs, we assume an additional $10,000 per person to address potential lost income and/or pain and suffering associated with a release incident that adversely impacts human health. Median per capita income for Wyoming residents is approximately $40,000.[52] We conservatively assume an average of one month's lost income for individuals affected by a pipeline release (i.e., slightly more than $3,000 per person). We assign approximately $7,000 per-person (to arrive at the $10,000 included in the cost distribution)

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[48] US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Office of Pipeline Safety Accident Investigation Division. Failure Investigation Report – Denbury Golf Coast Pipelines, LLC – Pipeline Rupture/Natural Force Damage. May 26, 2022. On February 22, 2020, Denbury's 24-inch Delhi Pipeline ruptured, releasing liquid CO2 that immediately began to vaporize at atmospheric conditions. The site of the rupture was approximately one mile southeast of Satartia, Mississippi. Denbury reported that the rupture released an estimated total of 31,405 barrels of CO2. Local authorities evacuated approximately 200 people near the rupture, including the entire town of Satartia (around 70 residents), and three homes across the Yazoo River. Forty-five people sought medical attention at local hospitals, including individuals who were caught in the vapor cloud while driving a vehicle. One individual was admitted to the hospital for reasons unrelated to the pipeline failure. There were no fatalities.

[49] To our knowledge, there are no documented 'real world' CO2 release events arising from land-based injection wells that resulted in documented human health impacts. In the absence of such data, we conservatively rely on a pipeline incident as a proxy for the types of surficial CO2 release events relevant to the CCS context. We do so because the types of impacts that might arise from a pipeline rupture are not dissimilar to those that might arise from an acute or chronic surface release of CO2 injectate from a CCS operation. We believe this approach to be both reasonable and conservative. To date, the most significant 'real world' CO2-related impact event in the United States that resulted in acute / chronic CO2-related impacts is the February 2020 Satartia, MS pipeline release. In our view, in the absence of other data specific to Wyoming, this release event offers a conservative proxy for estimating a cost distribution for endangerment to human health arising from an acute or chronic surface release of CO2 injectate.

[50] Peterson, Cora, Likang Xu and Curtis Florence. Average medical cost of fatal and non-fatal injuries by type in the USA. Inj Prev. 2021 February; 27(1): 24–33. doi:10.1136/injuryprev-2019-043544.

[51] The town of Spirea has a population of approximately 163 (compared to 73 for Satartia) according to American Community Survey 2021 5-year census data: https://censusreporter.org/profiles/16000US5612860-carpenter-wy/, https://censusreporter.org/profiles/16000US2865680-satartia-ms/

[52] https://www.census.gov/quickfacts/WY.

to address potential pain and suffering.[53] Given the likelihood that the potential impacts associated with CO2-related morbidity are likely to be relatively short-term, we believe $7,000 (about twice estimated lost income, and comparable to treatment costs) is reasonably conservative for purposes of deriving a financial assurance cost estimate.

Based on the information described above, we use a maximum cost estimate of $1,800,000.[54] We also include a minimum value of $0 in the cost distribution, because acute and chronic surface releases of CO2 injectate may have no human health impact. For example, in many circumstances, atmospheric dilution quickly reduces CO2 concentrations below relevant human health thresholds; there is diminished likelihood that, in this rural AOR with one (small) population center, people will be close enough to surface release locations to receive meaningful exposure; and implementation of the emergency response plan will help avoid impacts.

Readily available data indicate that public health impacts due to the transport and industrial use of CO2 are rare. A recent evaluation of PHMSA data identified 113 CO2 pipeline incidents that occurred between 1994 and 2021; to our knowledge, the Satartia, MS release is the only one that resulted in public health impacts.[55] Importantly, we have been unable to find documentation of any public health impacts arising from CO2 used in enhanced oil recovery operations or other industrial activities.

In light of this research we use a bimodal cost distribution to conservatively assume that 10% of subsurface or pipeline release events result in some level of human health impact. As a result, 90% of subsurface or pipeline release events are assigned $0 cost, because there no human health impacts expected to occur. For the remaining 10% of events, we assume a minimum cost of $20,000 (consistent with harm to one person) and a maximum cost of $1,800,000 (approximately twice the estimated treatment costs arising from the Satartia, MS pipeline incident).

Further, we assume a median cost of $200,000 and a 75$^{th}$ percentile cost of $400,000, approximately consistent with impacts to ten to twenty people, respectively. In our view, this cost distribution reasonably reflects the potentially exposed population, if an incident were to occur near a residence or small gathering in this highly rural area. Finally, we apply a Burr distribution to the cost range – while higher cost incidents potentially could occur, the AOR characteristics of the Spirea Project suggest that impacts to small numbers of people are substantially more likely than impacts to larger numbers of people.

### 7.4 Cost Distribution for Ecological and Response/Infrastructure Costs from Acute or Chronic Surface Release of CO2 Injectate

- Minimum: $5,000
- Maximum: $450,000
- Burr distribution

We apply the above cost distribution to all incidents that involve a well, caprock, fault or pipeline release incident that occur in a Monte Carlo trial.

This distribution is based on release-related cost information reported to the U.S. Department of Energy Pipeline and Hazardous Materials Safety Administration (PHMSA) for the 103 CO2 pipeline release incidents recorded from 2002 through 2021. We believe that PHMSA offers the most reasonably conservative data for estimating costs associated with ecological response, and property and infrastructure damage, including changes to surface topography and structures, arising from acute or chronic surface releases of CO2 injectate.

[53] Pain and suffering amounts (if awarded) are difficult to forecast and depend largely on legal jurisdiction, case-specific circumstances, and other factors impossible to predict with any degree of certainty.
[54] $1,800,000 = 90 people impacted * ($10,000 per person treatment cost + $10,000 per person lost income/pain & suffering)
[55] Vitali, Matteo, C. Zuliani, F Corvaro, B Marchetti and F Tallone. Statistical Analysis of Incidents on Onshore CO2 Pipelines Based on PHMSA Database. Journal of Loss Prevention in the Process Industries 77 (2022) 104799.

Specifically, the Monte Carlo simulation includes PHMSA-identified costs arising from emergency response, environmental remediation and non-operator property damage due to release incidents. We do not include private-party costs, including, for example, the value of product lost or operator property damage, as these categories do not inform emergency and remedial response actions responsive to estimating financial assurance cost estimates for WWQR event-based risk activities.

Although PHMSA data indicate that most incidents resulted in relevant costs *less than* $5,000 per incident, we conservatively assign $5,000 as the cost distribution minimum. This cost estimate is intended to reflect minor incidents with minimal response-related activities.

We use $450,000 as the cost distribution maximum, which reflects the single incident with the highest cost in the PHMSA data (adjusted for inflation); that is, the 2020 Sartartia, MS pipeline release. The total cost for this WWQR event-based risk activity is $431,361, which results from the afore-mentioned cost categories. We apply a Burr distribution to reflect the fact that pipeline release costs are skewed towards the lower end of the distribution – although higher costs can occur, they do so much less frequently than lower costs.

### 7.5 Cost Distribution for Mineral Rights Infringement

Data on Wyoming mineral rights are available from the state's Office of State Lands and Investments. We downloaded geospatial layers for active oil and gas and mineral rights and cross-referenced them with the AOR shapefile for the Spirea Project. This cross-reference revealed no active oil and gas leases and no active mineral leases within the 34 square mile AOR. As a result we do not believe that, for financial assurance cost estimation purposes, the potential for such costs is material for the Spirea Project.[56]

For completeness, if mineral activity were to occur in the AOR, it is reasonable to expect that it would continue at depths shallower than the subsurface confining layers above the CO2 storage plume. Conceptually, however, it is possible that a subsurface release event could temporarily interfere with mineral extraction operations that were planned or underway in subsurface areas near the release.

In the absence of actual mineral extraction activity in the AOR, the project sponsor may need to "refund" the equivalent of a lease payment to affected mineral rights holders, for an appropriate time period, in response to potentially temporarily interfering with the holder's ability to exercise their lease rights.[57] But as noted above, readily available public information indicates that there are no active oil and gas or mineral leases in the AOR, and so to our knowledge there are no lease payments.

It is our understanding that Wyoming mineral leases typically reflect a five-year term, require a lease payment, and a royalty based on mineral production. Royalty payments data are not readily available, but presumably there are no such payments in the AOR due to the lack of active leases.

Finally, it is possible that active mineral operations could experience other types of losses from a WWQR risk-based event activity (e.g. lost profits, business interruption). At this time, given the lack of active mineral operation activity in the AOR, quantifying any such potential losses would be too speculative to result in a reasonable cost estimate.

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[56] Although readily available, public information indicates that there are no active oil and gas or mineral leases in the AOR, the Monte Carlo model can apply a mineral rights infringement cost distribution to relevant incidents. To the extent new information becomes available with respect to oil and gas or mineral leases in the AOR, Monte Carlo calculations can be revised accordingly.

[57] Losses and attendant cost estimates for environmental and/or ecological event-based risks are addressed in other sections of this report. Other types of losses from a WWQR risk-based event activity involving mineral rights infringement (e.g. lost profits, business interruption) are not quantifiable at this time, given the lack of mineral operation activity in the AOR. Quantifying any such potential losses are too speculative to result in a reasonable or meaningful cost estimate. Per the regulations, the financial assurance cost estimates will be reevaluated annually, at which time estimates of losses (if any) will be refined to reflect actual increases in mineral extraction activity in the AOR.

Per WWQR Chapter 24, Section 26(b), financial assurance cost estimates (including those that address emergency and remedial response associated with WWQR risk-based event activities like mineral rights infringement) must be updated annually, or within 60 days of receiving notice that the Administrator has determined that a demonstration of financial assurance is no longer adequate. Consistent with Section 25(a)(i) and (a)(ii) requirements, financial assurance cost estimates also will need to be reevaluated after any updates to the emergency and remedial response plan. Consistent with these regulatory requirements, to the extent actual mineral extraction activity in the AOR occurs during the life of the Spirea Project, the financial assurance cost estimates will be reevaluated.

### 7.6 Cost Distribution for Property and Infrastructure Damage Arising from Induced Seismicity

- Minimum: $0
- Median: $100,000
- 75$^{th}$ Percentile: $200,000
- Maximum: $500,000
- Burr distribution

We apply the above cost distribution to all induced seismic events that occur in a Monte Carlo trial.

To develop this cost distribution, we compiled a dataset of all parcels that intersect with the AOR by combining: 1) Wyoming Department of Revenue statewide property assessment and valuation data; 2) the shapefile of the Spirea Project AOR; and 3) a separately-accessed shapefile of all parcels in Laramie County. This data analysis yielded 217 individual parcels, as of tax year 2024.

The property value data for these parcels are summarized in Exhibit 5, including the value of land and any improvements made to the land (generally, structures). Exhibit 6 summarizes the same data set, but excludes land values.

In our view, an induced seismic event of the magnitude relevant to the Spirea Project (discussed further below) could adversely impact structures, but is not likely to result in adverse impact to the land, itself. We estimate there is approximately $20 million of property infrastructure within the AOR that potentially could be adversely impacted by an induced seismic event.

**Exhibit 5. Summary of Property Values for Parcels in the AOR**

| Parcel Type | Count | Total Acreage | Average Acreage | Total Value ($) |
|---|---|---|---|---|
| Agricultural | 79 | 21,891 | 277 | $18,812,947 |
| Commercial | 8 | 11 | 1 | $332,674 |
| Commercial – Vacant Land | 2 | 0 | 0 | $6,455 |
| Industrial | 1 | 15 | 15 | $278,250 |
| Industrial – Vacant Land | 1 | 260 | 260 | $167,624 |
| Residential | 83 | 1,366 | 16 | $16,589,505 |
| Residential – Vacant Land | 37 | 1,520 | 41 | $2,256,524 |
| Exempt, w/ data | 6 | 3 | 0 | $16,655 |
| *Exempt, w/o data* | 7 | *34* | *5* | -- |
| *N/A (no data available)* | *1* | -- | -- | -- |
| **Total Parcels with Data** | **217** | **25,067** | **116** | **$38,460,634** |

Notes: From Laramie County, Wyoming geospatial data (https://maps.laramiecounty.com/arcgis/rest/services/features/CountyBaseMapFeatures/MapServer/2). Fields relied upon: "accttype" for parcel type; "netacres" for acreage; and "totalcostv" for value.

**Exhibit 6. Summary of Parcel Structure Values in the AOR**

| Parcel Type | Count | No. w/ Improvements | Total Impr. Value |
|---|---|---|---|
| Agricultural | 79 | 29 | $5,058,996 |
| Commercial | 8 | 8 | $251,340 |
| Commercial – Vacant Land | 2 | 0 | -- |
| Industrial | 1 | 1 | $95,892 |
| Industrial – Vacant Land | 1 | 0 | -- |
| Residential | 83 | 79 | $13,853,033 |
| Residential – Vacant Land | 37 | 0 | -- |
| Exempt, w/ data | 6 | 0 | -- |
| *Exempt, w/o data* | *7* | *0* | -- |
| *N/A (no data available)* | *1* | *0* | -- |
| **Total Parcels with Data** | **217** | **117** | **$19,259,261** |

Notes: From Laramie County, Wyoming geospatial data (https://maps.laramiecounty.com/arcgis/rest/services/features/CountyBaseMapFeatures/MapServer/2). Fields relied upon: "accttype" for parcel type; "netacres" for acreage; "totalimpsv" for improvement value; and "totalcostv" for total (land plus improvement) value.

As previously indicated, the project sponsor's seismicity evaluation found a 2% probability of exceedance in 50 years for seismic events ranging from 5% to almost 14% peak ground acceleration (in southeastern and northwestern Laramie County, respectively). For purposes of deriving a financial assurance cost estimate for emergency and remedial response related to this WWQR risk-based event activity, we converted peak ground acceleration numbers into a measure of possible monetary damage.

Exhibit 7 summarizes information from the United States Geological Survey (USGS) that relates peak ground acceleration to Modified Mercalli Intensity (MMI), a commonly referenced measure of earthquake intensity. The maximum peak ground acceleration of 14% estimated for the AOR corresponds to MMI category VI (which includes seismic events with peak ground accelerations between 9.2% and 18%).

The USGS also provides summary information describing the type of damage associated with different MMI categories (see Exhibit 8). As show in Exhibit 8, MMI Category VI events are associated with events "felt be all, many frightened, some heavy furniture moved, a few instances of fallen plaster. Damage slight." Relying on these representations, we assume a maximum repair cost equal to 2.5% of total structure value.

**Exhibit 7. Modified Mercalli Intensity Relative to Peak Ground Acceleration, Perceived Shaking and Potential Damage***

| Modified Mercalli Intensity | Acceleration (%g) (PGA) | Perceived Shaking | Potential Damage |
|---|---|---|---|
| I | <0.17 | Not felt | None |
| II | 0.17 – 1.4 | Weak | None |
| III | 0.17 – 1.4 | Weak | None |
| IV | 1.4 – 3.9 | Light | None |
| V | 3.9 – 9.2 | Moderate | Very Light |
| VI | 9.2 – 18 | Strong | Light |
| VII | 18 – 34 | Very Strong | Moderate |
| VIII | 34 – 65 | Severe | Moderate to Heavy |
| IX | 65 – 124 | Violent | Heavy |
| X | >124 | Extreme | Very Heavy |
| XI | >124 | Extreme | Very Heavy |
| XII | >124 | Extreme | Very Heavy |

*See, for example, https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/atoms/files/EQ101.pdf.

**Exhibit 8. Damage Potential Associated with Different MMI Category Events***

| Intensity | Shaking | Description/Damage |
|---|---|---|
| I | Not felt | Not felt except by a very few under especially favorable conditions. |
| II | Weak | Felt only by a few persons at rest,especially on upper floors of buildings. |
| III | Weak | Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated. |
| IV | Light | Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. |
| V | Moderate | Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop. |
| VI | Strong | Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. |
| VII | Very strong | Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. |
| VIII | Severe | Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. |
| IX | Violent | Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. |
| X | Extreme | Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. |

*See, for example, https://www.usgs.gov/programs/earthquake-hazards/modified-mercalli-intensity-scale

We believe this estimate is reasonably conservative and likely would be sufficient to address potential damage on the order of "a few instances of fallen plaster." To derive the maximum value for this cost distribution, we assume all structures in the AOR are impacted by a seismic event and require the maximum level of repair (i.e., 2.5% of total structure value). This assumption results in a cost distribution maximum of $500,000.[58] We use a minimum cost distribution value of $0, because induced seismic events can occur at low intensities with no attendant damage. We also assume a median distribution value of $100,000, generally consistent with an event that only impacts highly rural parts of the AOR (the vast majority of the AOR is highly rural, outside of the small town of Carpenter on the eastern edge of the AOR). Finally, we assume a 75th percentile estimate of $200,000 and use a Burr distribution for this cost range.

Although analyses completed by the project sponsor suggest a potential peak ground acceleration of 14% for northwest Laramie County, the AOR is in the southeastern portion of the county; and, in fact, the AOR is associated with a lower peak ground acceleration of 5%. This intensity level is associated with MMI Category V, which, in turn, is associated with lower levels of damage ("felt by nearly everyone, many awakened, some dishes, windows broken, unstable objects overturned, pendulum clocks may stop").

Although higher costs (i.e., MMI category VI risk-based event across the entire AOR) could result (and conservatively are the basis used for induced seismicity cost calculations), we believe they are substantially less likely to occur than lower cost events. Further, as previously noted, the project AOR has limited oil and gas development and lacks the extensive history of deep injection of fluids from nearby oil and gas operations that typically accompany areas experiencing significant induced seismicity.

### 7.7 Cost Distribution for Pore Space Trespass

- Minimum: $5,000
- Maximum: $650,000
- Uniform distribution

[58] $500,000 = $20 million total value of structures in the AOR * 2.5% maximum repair cost.

We apply the cost distribution above to all pore space trespass incidents that occur in a Monte Carlo trial.

As we understand, prior to initial CO2 injection, the project sponsor will have secured all necessary pore space, consistent with processes identified in the State of Wyoming regulations for unitization of geologic sequestration sites (WY § Stat 35-11-315 (2022)). Information provided by the project sponsor indicates that after initial CO2 injection, rights holders will share a lease payment expected to be approximately $1 per ton of CO2, divided among rights holders in proportion to their ownership (i.e., an owner contributing 1% of the area used for storage will receive 1% of the per-ton storage payments).[59]

Presently, the project sponsor forecasts storage of approximately 10.6 million tons of CO2 at the Spirea Project, resulting in total nominal per-ton payments for pore space storage rights of $10.6 million.[60] For purposes of deriving a financial assurance cost estimate, we assume that the per-ton payments will be made annually over the 17-year injection period, based on injected volumes evinced in the prior year.[61]

[59] Some rights holders also will receive pre-injection payments, but such payments are not relevant to trespass cost estimation (which can only occur after injection begins).

[60] This total value is consistent with the project sponsor's representation of $1 per-ton of CO2 stored, divided among rights holders in proportion to ownership.

[61] The project sponsor has represented that such payments may be done quarterly instead of annually. The difference in the time value of money between quarterly and annually is de minimis.

Per WWQR Chapter 24: Section 26(b)(i), financial assurance cost estimates must be in current dollars. We determine the present (current) value of the stream of nominal ($1 per ton) pore space payments, based on the operational life of the injection well that comprises the Spirea Project. We do so, using the present value method.[62] The calculations underpinning the present values summarized in Exhibit 9 are based on: 1) anticipated injection rate, as provided by the project sponsor; 2) the date that the Spirea injection well is anticipated to begin injection, 3) the length of time the well is anticipated to remain operational; and 4) annual discount rates aligned to future expected inflation rates[63] published by the Board of Governors of the U.S. Federal Reserve System as a measure of the rate at which prices are likely to change over the life of the injection well. As shown in Exhibit 9, factoring for the above assumptions, pore space rights payments total approximately $8.4 million (2023$).

**Exhibit 9. Pore Space Rights Payments Discounting Calculations**

| Well | Injection Start Date | Injection End Date | Total Injection Days | Total MMT | Present Value (2023$) |
|---|---|---|---|---|---|
| Spirea I-1 | 1/1/2025 | 1/1/2042 | 6,209 | 10,600,000 | $8,413,905 |

Importantly, if pore space trespass were to occur, it is possible that no additional payments would be required. As we understand from the project sponsor, the payment amount initially negotiated with pore space rights holders and identified in a unitization agreement (anticipated to be $1 per ton) would remain unchanged, the total payment simply would be divided among a (larger) number of storage acres.

For purposes of financial assurance cost estimation, however, we conservatively assume that is not the case. Rather, we assume that an additional, supplemental payment would be required to pore space rights holders who were not part of the original unitization agreement, and who, subsequent to CO2 injection, experience trespass.

From a timing perspective, trespass is highly unlikely to occur during the early years of injection – in our view, trespass risk increases as the total volume of injection increases and more time is provided for the CO2 plume to move through the subsurface environment. For these reasons, and for purpose of financial assurance cost estimation, we make the reasonable, simplifying assumption that should any trespass occur it is likely to occur during the last 10 years of the project's 17 year injection period. At that time, should trespass occur, 'trespassed' pore space rights holders would be entitled to receive a per-acre payment comparable to that received by pore space rights holders who were subject to the initial unitization agreement and who received payments during the operational life of the well.[64]

Based on injection volume and the timing information provided by the project sponsor for each of the five injection wells in the AOR, pore space rights payments during the last 10 years of the project's injection period are expected to total approximately $4.6 million (2023$). We assume these payments would be allocated over an average area of about 15,000 acres, which implies a total pore space rights payment price of approximately $300/acre over the ten year 'trespass' period.[65] If, instead, the storage plume extended (and thereby trespassed)

[62] The present value method is used in corporate finance to determine today's value of a stream of future cash flows or payments. Present value analysis is based on the expectation that funds invested, today, can grow over time to match the expected need and timing for funds in the future. This concept is referred to as the Time Value of Money; that is, money available today is worth more than the same amount in the future, because of its potential to earn a return on investment.

[63] See Federal Reserve Bank of Cleveland, "Inflation Expectations" data series: "Expected Inflation and Real and Inflation Risk Premia" at https://www.clevelandfed.org/our-research/indicators-and-data/inflation-expectations.aspx (Nov. 2023).

[64] We focus on the injection period for these calculations, because pore space rights payments are expected to be made as CO2 is injected. Based on information provided by the project sponsor, no additional storage rights payments are expected during site closure or post-injection site care (PISC).

[65] $300 ($2023) per acre (rounded) = $4.6 million ($2023) pore space rights payments over last ten years of injection / 15,000 acres. The injectate plume will increase in size over time, up to a maximum (modeled plume plus buffer area) of approximately 21,500 acres.

into an additional 2,150 acres (about 10% of the maximum anticipated plume size), that would result in a total maximum trespass payment of approximately $650,000.[66]

Based on the information and approach described above, we use 650,000 as the maximum for our potential trespass cost distribution. This estimate is conservative – as previously noted, the actual movement of CO2 in the subsurface environment will be calibrated with modeled predictions on a regular and systematic basis, and therefore it is likely that any potential trespass issue would be identified prior to occurrence and the amount and/or location of ongoing CO2 injection potentially adjusted to reduce or eliminate the trespass concern. In addition, if trespass occurs it is possible that no additional payments would be required (i.e., the storage rights per-injected-ton payment amount would remain unchanged, but divided among a (larger) number of storage acres). To the extent potential trespass begins later than assumed in our calculations, the present value (2023$) of storage rights payments would decrease.

Finally, for purposes of Monte Carlo analysis, we assume a minimum trespass payment of $5,000, which allows for the reasonable possibility of trespass across very small acreages. We apply a uniform distribution to the cost range, which results in an equal chance for selection of every cost within the range.

## 8.0 MONTE CARLO ANALYSIS RESULTS

Based on a model run of 50,000 Monte Carlo trials **we estimate an upper-bound financial assurance cost estimate to satisfy emergency and remedial response and WWQR event-based risk activities of $5.3 million in current 2023 dollars.** This upper-bound cost estimate reflects the single Monte Carlo trial with the greatest financial assurance costs out of the 50,000 trials run (see Exhibit 10). We believe this estimate to be reasonable and appropriately conservative.

### Exhibit 10. ERR and Event-Based Risk Activity Financial Assurance Cost Estimation Results (2023$)

| Summary Statistic | Cost | # of Events Occurring |
|---|---|---|
| Average | $200,681 | 0.45 |
| Standard Deviation | $443,031 | 0.67 |
| 5th Percentile | $0 | 0 |
| 50th Percentile | $0 | 0 |
| 95th Percentile | $1,274,390 | 2 |
| 99th Percentile | $1,923,872 | 2 |
| Minimum | $0 | 0 |
| Maximum | $5,248,291 | 5 |

Consistent with WWQR Chapter 24: Section 26(b)(iv) requirements, the Monte Carlo-based financial assurance cost estimates: incorporate cost curves shall combine risk probabilities, event outcomes, and damages assessment to calculate expected losses under a series of events; provide estimates of 50th, 95th, 99th percentile probabilities of occurrence; are calculated by project phase; are based on cost estimates that reflect third party-performance of response actions; and account for the entire Spirea Project AOR.

Exhibit 11 provides a summary of results by event and cost type. Across all 50,000 Monte Carlo trials, deep oil and gas well leaks accounted for the largest fraction of estimated costs (approximately 44.1%) followed by leakage through caprock/faults then shallow wells (30.5%), pore space trespass (16.2%), pipeline release (6.9%), induced seismicity (1.3%), CO2 injection well leak (0.19%) and slow leakage through caprock (0.77%). The types of costs addressed in these estimates include: well repair; USDW non-endangerment;

[66] $650,000 (rounded) = $300 per acre * 2,150 acres trespassed

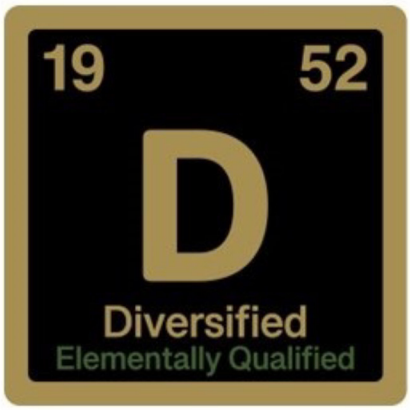
release-related human health, ecological and infrastructure impacts; mineral rights infringement; pore space storage trespass; and, induced seismicity-related infrastructure damage.

### Exhibit 11. Cost Estimate Breakdown by Event and Cost Category Types

| Event | Associated Cost Categories | Percent of Total Costs Across All Trials |
|---|---|---|
| Leakage Through Caprock/Faults then Shallow Well | Well repair (as applicable), USDW non-endangerment, release-related human health, ecological and infrastructure impacts, mineral rights infringement | 30.5% |
| Deep Oil & Gas Well Leak | | 44.1% |
| CO2 Injection Well Leak | | 0.19% |
| Slow Leakage Through Caprock | | 0.77% |
| Rapid Leakage Through Caprock | | 0.0% |
| Release Through Existing Faults | | 0.0% |
| Release Through Induced Faults | | 0.0% |
| Pipeline Release | Release-related human health, ecological and infrastructure impacts | 6.9% |
| Pore Space Trespass | Pore space storage rights payment | 16.2% |
| Induced Seismicity | Seismicity-related infrastructure damage | 1.3% |

**Response to Specific Comments, SC-13**

**Mudlog_Juniper M-1**




# Diversified

800-280-2096

info@dwl-usa.com

**COMPANY:** Tallgrass High Plains Carbon Storage ,LLC

**WELL:** Juniper M1

**FIELD:** WC **COUNTY:** LARAMIE **STATE:** WY

**LOCATION:** 41.0559676, -104.2719478

**Interval Logged:** 110 **To:** 9850 **G.L.:** 5345 **K.B:** 5378

**Date Logged:** 1-20-23 **To:** 2-23-23 **Spud Date:** 1-22-23

**Rig:** True Rig 33 **Unit No.:** DLT-002

**Loggers:** Thomas Hale / Hussain Al Balushi

**Api No.:** 490212954800

**Filename:** juniper_m1.mlw

**Geologist:** Chris Bowie

Created By MainLog

## Abbreviations

| | |
|---|---|
| NB...New Bit | DST...Drill Stem Test |
| CO...Circ Out | DS...Directional Survey |
| NR...No Returns | CG...Connection gas |
| TG...Trip Gas | LAT...Logged After Trip |
| WOB...Wt on Bit | PP...Pump Pressure |
| RPM...Rev/Min | SPM...Strokes/Min |
| SG...Survey Gas | DTG...Down Time Gas |

## Mud Data

| | |
|---|---|
| WT..Weight | V..Viscosity |
| PH..Acidity | F..Filtrate |
| CHL..Chlorides | SC..Solids Content |
| PV..Plastic Vis | YP..Yield Point |

## Lithology Symbols

| | | |
|---|---|---|
| Anhydrite | Salt | Granite |
| Siltstone | Chert | Sandstone |
| Dolomite | Conglomerate | Limestone |
| Coal | Shale | Bentonite |
| Carb Shale | Granite Wash | Quartz Wash |
| Red Sh | Org Sh | Green Sh |
| Chalk | VOLC | Cement |
| clay sh | CL 2 | CL 3 |
| CL 4 | CL 6 | CL 6 |

### Accessories

Glauconite, Pyrite, Fossils, Oolites, Fractures

## Accessories

Ammonoid, Bryzoans, Coal, Coral, Crinoid, Forams, Fossils, Fracture, Gastropod, Glauconite, LS-symbol, Mollusk, Nautaloid, Oolites, Pyrite, Radiolaria, SH symbol, Trilobite, Worm Burrow

0 GAMMA API 150

Drilling Rate

FT/HR

Vis Por

Tr /

p f g

Lithology

% Oil Flu

Tr /

p f g

Cut

Tr /

pfg

GAS CURVES

TG

C1

C2

C3

IC4

NC4

IC5

NC5

Pictures

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Cutting Size

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RONNIE,THOMAS,JR, DANIEL ARRIVED ON LOCATION 01/20/2023

50

1/24/23

100

1/25/23

MD 134.00'
TVD 134.00'
INC 0.57°
AZM 292.69°
VS 0.26'
DLS 43.00°

50

200

WOB 1.0
RPM 71
PP 650
SPM 128

GAMMA

150

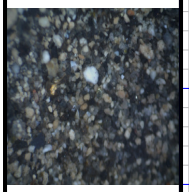
400 200 100 50

CG 3

WT IN 8.6
WT OUT 8.6

HW 10 100 1k 10k

MD 228.00'
TVD 227.99'
INC 0.44°
AZM 300.16°
VS 0.62'



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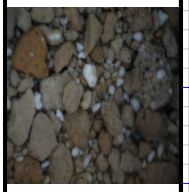
SD: PRED TN-RDSH TN, OCC GLOS, V F-V CRS GR, SB ANG-ANG, CALC, PRED FRI, GD POR, POORLY SRT, TR SLTST, TR FSPR, TR QTZ, NO FLUOR



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SD: PRED TN-RDSH TN, OCC YELSH TN, VF-MED GR, SBRND-SB ANG, CALC, PRED FRI-MOD CONSOL, TR CALC INCL, M INTGRAN POR, POORLY SRT, TR MIC, TR FSPR, TR QTZ, DULL YEL FLUOR

50

300

50

400

50

MD 321.00'
TVD 320.99'
INC 0.57°
AZM 293.48°
VS 0.98'
DLS 0.98°

MD 413.00'
TVD 412.98'
INC 0.70°
AZM 302.80°
VS 1.47'
DLS 0.18°

WOB 2.0
RPM 75
PP 651
SPM 162

GAMMA
0 150
400 200 100 50

CG 2

GAS TRAP PROBLEM

CG 2

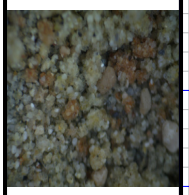
WT IN 8.6
WT OUT 8.6

HW 10 100 1k 10k

GAS BLOW BACK



SD: PRED TN-LT CRM, FROS GR, ANG-SB ANG, PRED MOD-WELL CONSOL, CALC, MOD SRT, M INTGRAN POR, TR FSPR, TR QTZ, TR SLTST, NO FLUOR



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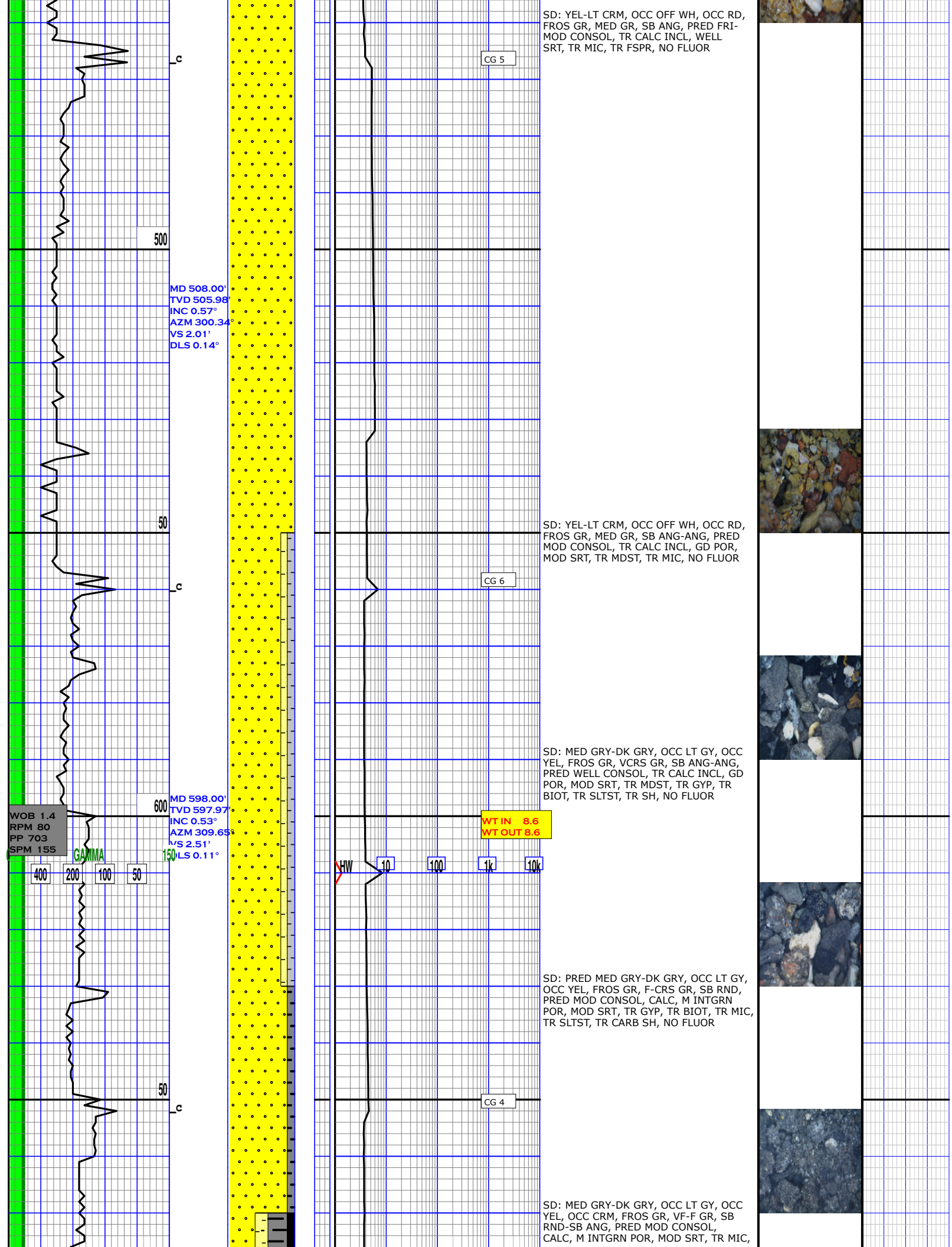



SD: YEL-LT CRM, OCC OFF WH, OCC RD, FROS GR, MED GR, SB ANG, PRED FRI-MOD CONSOL, TR CALC INCL, WELL SRT, TR MIC, TR FSPR, NO FLUOR



SD: YEL-LT CRM, OCC OFF WH, OCC RD, FROS GR, MED GR, SB ANG-ANG, PRED MOD CONSOL, TR CALC INCL, GD POR, MOD SRT, TR MDST, TR MIC, NO FLUOR



SD: MED GRY-DK GRY, OCC LT GY, OCC YEL, FROS GR, VCRS GR, SB ANG-ANG, PRED WELL CONSOL, TR CALC INCL, GD POR, MOD SRT, TR MDST, TR GYP, TR BIOT, TR SLTST, TR SH, NO FLUOR



SD: PRED MED GRY-DK GRY, OCC LT GY, OCC YEL, FROS GR, F-CRS GR, SB RND, PRED MOD CONSOL, CALC, M INTGRN POR, MOD SRT, TR GYP, TR BIOT, TR MIC, TR SLTST, TR CARB SH, NO FLUOR



SD: MED GRY-DK GRY, OCC LT GY, OCC YEL, OCC CRM, FROS GR, VF-F GR, SB RND-SB ANG, PRED MOD CONSOL, CALC, M INTGRN POR, MOD SRT, TR MIC,

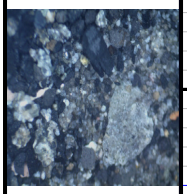
TR SLTST, TR CARB SH, NO FLUOR

MD 691.00'
TVD 690.97'
INC 0.40°
AZM 327.06°
VS 3.06'
DLS 0.20°

700

50

CG 4



SD: MED GRY-DK GRY, OCC LT GY, OCC TN, FROS GR, OCC GLOS GR, VF-CRS GR, SB RND-SB ANG, MOD CONSOL, CALC, M INTGRN POR, MOD SRT, TR CARB SH, TR C, NO FLUOR

MD 783.00'
TVD 782.97'
INC 0.48°
AZM 330.48°
VS 3.67'
DLS 0.09°

800

WOB 1.4
RPM 80
PP 741
SPM 155

GAMMA
150
400
200
100
50

WT IN 8.6
WT OUT 8.6

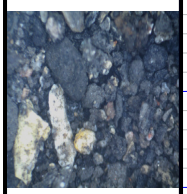
HW
10
100
1k
10k



SD: PRED TN-BRN, OCC MED GRY-DK GRY, FROS GR, OCC GLOS GR, VF-CRS GR, SB RND, FRI-MOD CONSOL, CALC, M INTGRN POR, MOD SRT, TR CARB SH, TR FSPR, NO FLUOR

CG 4

50



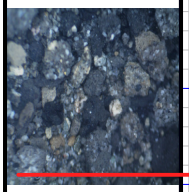
SD: TN-MED GRY, OCC DK GRY, FRPS GR, OCC GLOS GR, VF-VCRS GR, SB RND, FRI-MOD CONSOL, CALC, GD POR, MOD SRT, TR SH, TR GYP, NO FLUOR

MD 877.00'
TVD 876.97'
INC 0.62°
AZM 297.96°
VS 4.25'
DLS 0.36°

900

FOX HILLS FORMATION 919' MD
918.97' TVD (4459.03' SS)

SD: PRED MED GRY, OCC DK GRY, OCC TN, FROS GR, OCC GLOS GR, VF-VCRS GR, SBRND-SB ANG, FRI-MOD CONSOL, CALC, M INTGRN POR, MOD SRT, TR CARB SH, NO FLUOR



CG 4

50

MD 969.00'
TVD 968.96'
INC 0.66°
AZM 321.43°
VS 4.89'
DLS 0.29°



SD: LT GRY-LT CRM, OCC OFF WH, FROS GR, OCC GLOS GR, CRS GR, RND-SB RND, CALC, PRED WELL CONSOL, TR CALC INCL, M INTGRN POR, MOD SRT, TR GYP, TR MUSC, NO FLUOR

1000

WOB 0.4
RPM 80
PP 780
SPM 155

WT IN 8.6
WT OUT 8.6

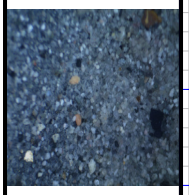


GAMMA 150
400 200 100 50

HW 10 100 1k 10k

SD: PRED MED GRY, OCC CRM, FROS GR, OCC GLOS, VF GR, RND-SB RND, PRED FRI, TR CALC INCL, GD POR, WELL SRT, TR CARB SH, TR GYP, TR MUSC, TR C, NO FLUOR

CG 3



SD: PRED OFF WH-MED GRY, FROS-GLOS GR, VF GR, RND, CALC, PRED UNCONSOL, TR CALC INCL, GD POR, WELL SRT, TR CARB SH, TR C, TR MIC, NO FLUOR

50

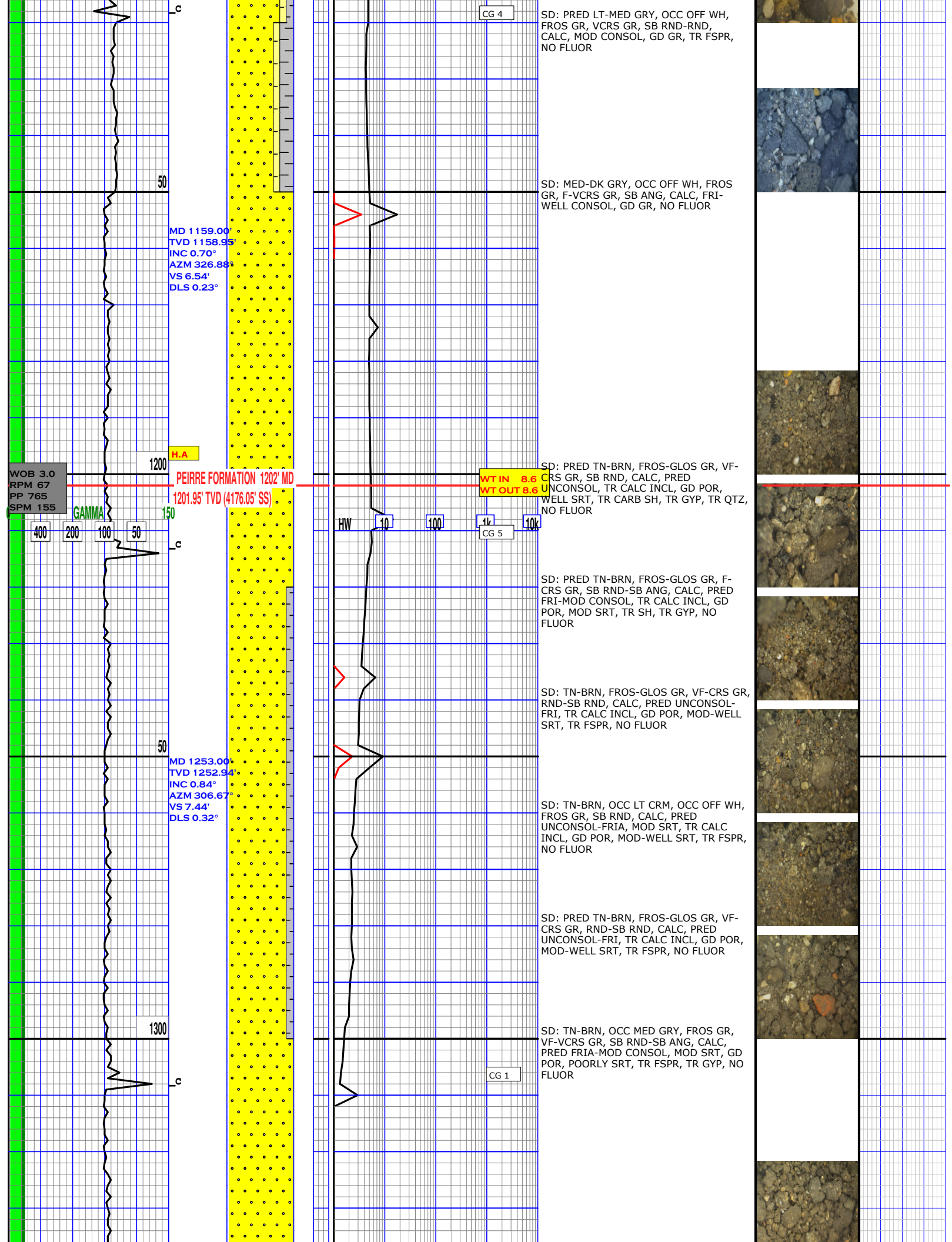
MD 1064.00'
TVD 1063.95'
INC 0.70°
AZM 309.30°
VS 5.69'
DLS 0.16°



SD: PRED MED-DK GRY, FROS GR, F-VCRS GR, RND, CALC, PRED CONSOL, M INTRGN POR, MOD-WELL SRT, TR CARB SH, TR FSPR, NO FLUOR

1100




CG 4
SD: PRED LT-MED GRY, OCC OFF WH, FROS GR, VCRS GR, SB RND-RND, CALC, MOD CONSOL, GD GR, TR FSPR, NO FLUOR
50
MD 1159.00'
TVD 1158.95'
INC 0.70°
AZM 326.88°
VS 6.54'
DLS 0.23°
SD: MED-DK GRY, OCC OFF WH, FROS GR, F-VCRS GR, SB ANG, CALC, FRI-WELL CONSOL, GD GR, NO FLUOR
1200
H.A
PEIRRE FORMATION 1202' MD
1201.95' TVD (4176.05' SS)
WOB 3.0
RPM 67
PP 765
SPM 155
WT IN 8.6
WT OUT 8.6
SD: PRED TN-BRN, FROS-GLOS GR, VF-CRS GR, SB RND, CALC, PRED UNCONSOL, TR CALC INCL, GD POR, WELL SRT, TR CARB SH, TR GYP, TR QTZ, NO FLUOR
GAMMA
150
400
200
100
50
HW
10
100
1k
10k
CG 5
SD: PRED TN-BRN, FROS-GLOS GR, F-CRS GR, SB RND-SB ANG, CALC, PRED FRI-MOD CONSOL, TR CALC INCL, GD POR, MOD SRT, TR SH, TR GYP, NO FLUOR
SD: TN-BRN, FROS-GLOS GR, VF-CRS GR, RND-SB RND, CALC, PRED UNCONSOL-FRI, TR CALC INCL, GD POR, MOD-WELL SRT, TR FSPR, NO FLUOR
50
MD 1253.00'
TVD 1252.94'
INC 0.84°
AZM 306.67°
VS 7.44'
DLS 0.32°
SD: TN-BRN, OCC LT CRM, OCC OFF WH, FROS GR, SB RND, CALC, PRED UNCONSOL-FRIA, MOD SRT, TR CALC INCL, GD POR, MOD-WELL SRT, TR FSPR, NO FLUOR
SD: PRED TN-BRN, FROS-GLOS GR, VF-CRS GR, RND-SB RND, CALC, PRED UNCONSOL-FRI, TR CALC INCL, GD POR, MOD-WELL SRT, TR FSPR, NO FLUOR
1300
SD: TN-BRN, OCC MED GRY, FROS GR, VF-VCRS GR, SB RND-SB ANG, CALC, PRED FRIA-MOD CONSOL, MOD SRT, GD POR, POORLY SRT, TR FSPR, TR GYP, NO FLUOR
CG 1

MD 1348.00'
TVD 1347.93'
INC 0.92°
AZM 329.78°
VS 8.51'
DLS 0.38°

50

1400

C

WOB 62.6
RPM 70
PP 744
SPM 155

GAMMA 150

400 200 100 50

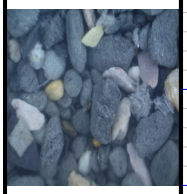
CG 1

WT IN 8.6
WT OUT 8.6

HW 10 100 1k 10k

FROZEN LINE

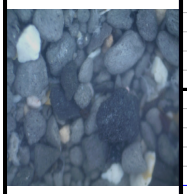
SD: TN-BRN, OCC MED GRYSH BRN, FROS GR, F-VCRS GR, SB RND-SB ANG, CALC, PRED FRIA-MOD CONSOL, MOD SRT, GD POR, TR SH, TR GYP, NO FLUOR



MD 1443.00'
TVD 1442.91'
INC 1.10°
AZM 323.98°
VS 9.91'
DLS 0.22°

50

SST:PRED MED-DK, OP-FROS GR, SB RND-RND, CALC, WELL CONSOL, VCRS GR, MOD SRT, GD POR, TR GYP, TR FSPR, NO FLUOR



SST:PRED MED-DK GRY, OCC V DK GRY, OP-FROS GR, SB RND-RND, CALC, WELL CONSOL, VCRS GR, MOD SRT, GD POR, TR GYP, TR FSPR, NO FLUOR

GAMMA 150

600 400 200 100

C

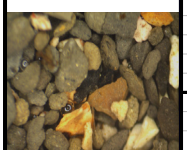
1500

CG 65

MD 1510.00'
TVD 1509.90'
INC 1.05°
AZM 326.62°
VS 10.94'
DLS 0.11°



SH:MED-DK GRY, AMOR-PLTY, BRIT-HD, EA-GT TEX, TR SD, TR CHK, TR MIC, NO FLUOR



50

SCP REACHED @1565'MD

1/28/23

T.H

MD 1565.00'
TVD 1564.89'
INC 1.05°
AZM 326.62°
VS 11.78'
DLS 0.00°

WOB 4.0
RPM 70
PP 1602
SPM 96

GAMMA

600 400 200 100

150

50

1600

MD 1627.00'
TVD 1626.88'
INC 1.01°
AZM 323.36°
VS 12.66'
DLS 0.06°

50

1700

1/31/23

MD 1722.00'
TVD 1721.87'
INC 1.10°
AZM 308.20°
VS 13.90'
DLS 0.31°

50

PURGED GAS LINE

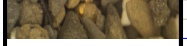
CG 1

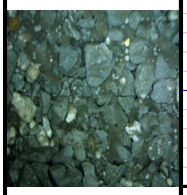
WT IN 9.9
WT OUT 9.8

MW 10 100 1k 10k

CG 1

SH:MED-DK GRY, AMOR-PLTY, SLILY HD-BRIT, EA-GT TEX, TR SD, TR CHK, TR RSH, NO FLUOR





SH:MED-DK GRY, AMOR-SPLIN, FRM-SLILY HD, SM-EA TEX, TR SD, TR CHK, DULL BLSH WH FLUOR



SH:MED-DK GRY, AMOR-SPLIN, SFT-FRM, SM-EA TEX, TR SST, TR CHK, TR BENT, FNT YEL FLUOR



SH:MED-DK GRY, AMOR-SPLIN, FRM-SLILY HD, SM-EA TEX, TR SST, DULL BLSH WH FLUOR



SH:MED-DK GRY, AMOR-BLKY, SLILY HD-BRIT, EA-SLTY TEX, TR SST, TR FSPR, NO FLUOR



SH:MED-DK GRY, AMOR-BLKY, OCC PLTY, SLILY HD-BRIT, SLTY-GT TEX, TR SST, TR CHK, NO FLUOR

WOB 2.7
RPM 65
PP 1526
SPM 99

GAMMA

600 400 200 100 150

1800

MD 1816.00'
TVD 1815.85'
INC 1.14°
AZM 314.75°
VS 15.12'
DLS 0.14°

50

1900

MD 1911.00'
TVD 1910.82'
INC 1.41°
AZM 315.45°
VS 16.61'
DLS 0.28°

H.A

50

CG 1

WT IN 9.8+
WT OUT 9.8+

HW 10 100 1k 10k

CG 1

CG 0



SH:MED GRY, OCC DK GRY, AMOR-BLKY, OCC PLTY, FRM-BRIT, EA-GT TEX, TR SLT, TR BENT, DULL WH FLUOR



SH:MED GRY, OCC DK GRY, AMOR-BLKY, OCC PLTY, FRM-BRIT, EA-GT TEX, TR SLT, TR BENT, DULL WH FLUOR



SH:MED GRY, OCC LT GRY, AMOR-PLTY, OCC FLK, FRM-SLILY HD,OCC BRIT, SM-EA TEX, OCC SLTY TEX, TR SLT, NO FLUOR



2000

GAMMA

600 400 200 100

150

MD 2006.00'
TVD 2005.80'
INC 1.36°
AZM 316.69°
VS 18.27'
DLS 0.06°

50

C

HW 10 100 1k 10k

SH:MED GRY MED GRY, OCC LT GRY, AMOR-PLTY, OCC FLK, FRM-SLILY HD,OCC BRIT, SM-EA TEX, OCC SLTY TEX, TR SLT, NO FLUOR



CG 5



SH: MED GRY LIT GRY, OCC LT GRY, AMOR-PLTY, OCC FLK, FRM- VERY SLILY HD,OCC BRIT, SM-EA TEX, OCC SLTY TEX, TR SLT, NO FLUOR

2100

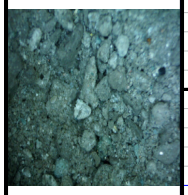
MD 2100.00'
TVD 2099.77'
INC 1.36°
AZM 315.81°
VS 19.88'
DLS 0.02°

50

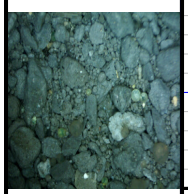
C

T.H

CG 4



SH: MED GRY , OCC LT GRY, OCC FLK, FRM- VERY SLILY HD,OCC BRIT, SM-EA TEX, OCC SLTY TEX, TR SLT, NO FLUOR



MD 2195.00'
TVD 2194.74'
INC 1.45°
AZM 322.49°
VS 21.64'
DLS 0.20°

2200

WOB 2.2
RPM 50
PP 1504
SPM 111

WT IN 9.8
WT OUT 9.8
VIS 80

SH:MED-DK GRY, AMOR-SPLIN, FRM-SLILY HD, SM-EA TEX, TR SLTST, TR SD, DULL BLSH WH FLUOR

GAMMA

600 400 200 100

150

HW 10 100 1k 10k

50

C

MD 2290.00'
TVD 2289.71'
INC 1.45°
AZM 315.54°
VS 23.45'
DLS 0.19°

2300

CG 4



SH:MED-DK GRY, AMOR-PLTY, OCC BLKY, SLILY HD-BRIT, EA-SLTY TEX, TR SLT, DULL WH FLUOR

B

50

C

CG 4



SH:PRED MED GRY, OCC LT GRY, AMOR-PLTY, OCC FLK, SLILY HD-BRIT, EA-SLTY TEX, TR SLT, TR BENT, DULL WH FLUOR

MD 2383.00'
TVD 2382.68'
INC 1.32°
AZM 319.94°
VS 25.11'
DLS 0.18°

2400

WOB 5.4
RPM 81
PP 1606
SPM 111

GAMMA

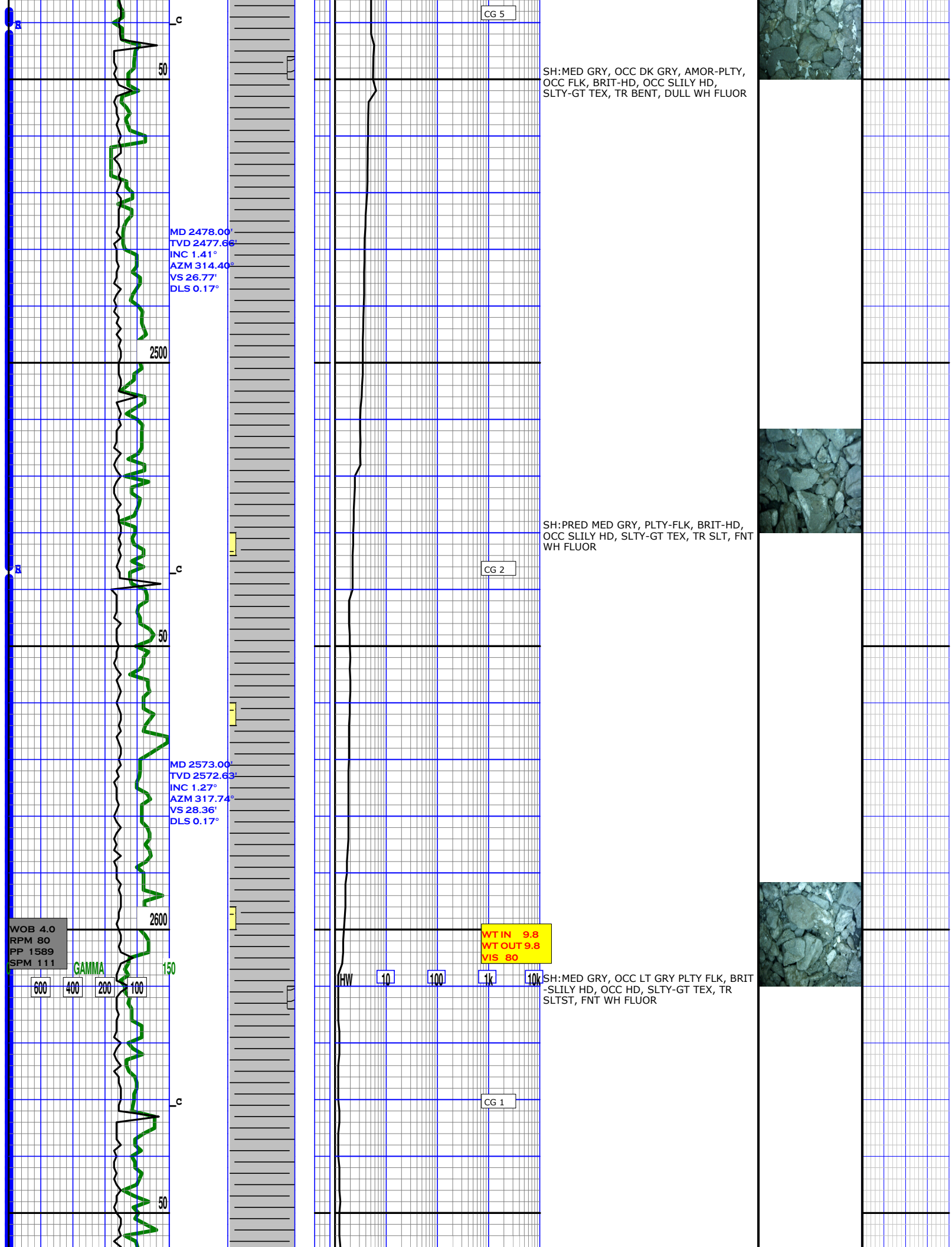
150

600 400 200 100

WT IN 9.8
WT OUT 9.8
VIS 80

HW 10 100 1k 10k




CG 5
SH:MED GRY, OCC DK GRY, AMOR-PLTY, OCC FLK, BRIT-HD, OCC SLILY HD, SLTY-GT TEX, TR BENT, DULL WH FLUOR
MD 2478.00'
TVD 2477.66'
INC 1.41°
AZM 314.40°
VS 26.77'
DLS 0.17°
2500
CG 2
SH:PRED MED GRY, PLTY-FLK, BRIT-HD, OCC SLILY HD, SLTY-GT TEX, TR SLT, FNT WH FLUOR
MD 2573.00'
TVD 2572.63'
INC 1.27°
AZM 317.74°
VS 28.36'
DLS 0.17°
2600
WOB 4.0
RPM 80
PP 1589
SPM 111
GAMMA
600
400
200
100
150
WT IN 9.8
WT OUT 9.8
VIS 80
HW
10
100
1k
10k
SH:MED GRY, OCC LT GRY PLTY FLK, BRIT-SLILY HD, OCC HD, SLTY-GT TEX, TR SLTST, FNT WH FLUOR
CG 1
50

MD 2667.00'
TVD 2666.61'
INC 1.27°
AZM 322.22°
VS 29.96'
DLS 0.11°

2700

50

2/1/23

MD 2762.00'
TVD 2761.58'
INC 1.23°
AZM 329.78°
VS 31.67'
DLS 0.18°

2800

WOB 8.8
RPM 79
PP 1538
SPM 111

GAMMA 150

600 400 200 100

50

MD 2857.00'
TVD 2856.56'
INC 1.14°
AZM 323.19°
VS 33.31'
DLS 0.17°

CG 2

HW 10 100 1k 10k

WT IN 9.6
WT OUT 9.65
VIS 73

CG 2

SH:PRED MED-DK GRY, AMOR-PLTY, OCC BLKY, SLILY HD-BRIT, EA-SLTY TEX, TR BENT, DULL WH FLUOR



SH:PRED MED GRY, OCC LT GRY, PLTY-FLK, BRIT-HD, OCC SLILY HD, SLTY-GT TEX, TR BENT, FNT WH FLUOR





SH:MED GRY, PLTY-FLK, OCC BLKY, BRIT-HD, OCC V HD, SLTY-GT TEX, TR SLT, NO FLUOR





SH:PRED MED-DK GRY, AMOR-PLTY, OCC BLKY, SLILY HD-BRIT, OCC V HD, EA-SLTY TEX, TR BENT, FNT YEL FLUOR



2900

50

MD 2951.00'
TVD 2950.55'
INC 0.92°
AZM 332.86°
VS 34.73'
H.A .30°

CG 1

3000

WOB 4.6
RPM 79
PP 2229
SPM 144

GAMMA 150

600 400 200 100

WT IN 9.6
WT OUT 9.65
VIS 71

HW 10 100 1k 10k

CG 0

50

MD 3046.00'
TVD 3045.54'
INC 0.75°
AZM 318.88°
VS 35.88'
DLS 0.28°

3100

50

3200

WOB 3.9
RPM 55
PP 1400
SPM 111

GAMMA

600 400 200 100

150

50

3300

MD 3235.00'
TVD 3234.52'
INC 0.97°
AZM 329.60°
VS 38.05'
DLS 0.24°

CG 2

SH:PRED MED GRY, AMOR-PLTY, OCC BLKY, SLILY HD-BRIT, OCC V HD, EA-SLTY TEX, TR BENT, FNT YEL FLUOR





SH:PRED GRY, AMOR-PLTY, OCC BLKY, SLILY HD-BRIT, OCC V HD, EA-SLTY TEX, TR BENT, NO FLUOR

CG 1

LOST WITS

WT IN 9.5
WT OUT 9.5
VIS 59

HW 10 100 1k 10k

LOST WITS

CG 0

LOST WITS

MD 3330.00'
TVD 3329.51'
INC 0.75°
AZM 315.54°
VS 39.19'
DLS 0.32°

50

3400

GAMMA 150

600 400 200 100

GAS TEST

CG 248

HW 10 100 1k 10k

SH:PRED GRY, PLTY, OCC BLKY, SLILY HD-BRIT, OCC V HD, EA-SLTY TEX, TR BENT, NO FLUOR



MD 3424.00'
TVD 3423.50'
INC 0.84°
AZM 342.96°
VS 40.17'
DLS 0.13°

50

CG 1

3500

SH:PRED MED-DK GRY, AMOR-PLTY, OCC BLKY, SLILY HD-BRIT, EA-SLTY TEX, TR BENT, LIT FLUOR



MD 3519.00'
TVD 3518.49'
INC 0.66°
AZM 331.54°
VS 41.20'
DLS 0.23°

50

3600

GAMMA 150

600 400 200 100

MD 3613.00'
TVD 3612.48'
INC 0.88°
AZM 337.60°
VS 42.34'
DLS 0.25°

50

3700

MD 3708.00'
TVD 3707.47'
INC 0.97°
AZM 328.99°
VS 43.71'
DLS 0.17°

50

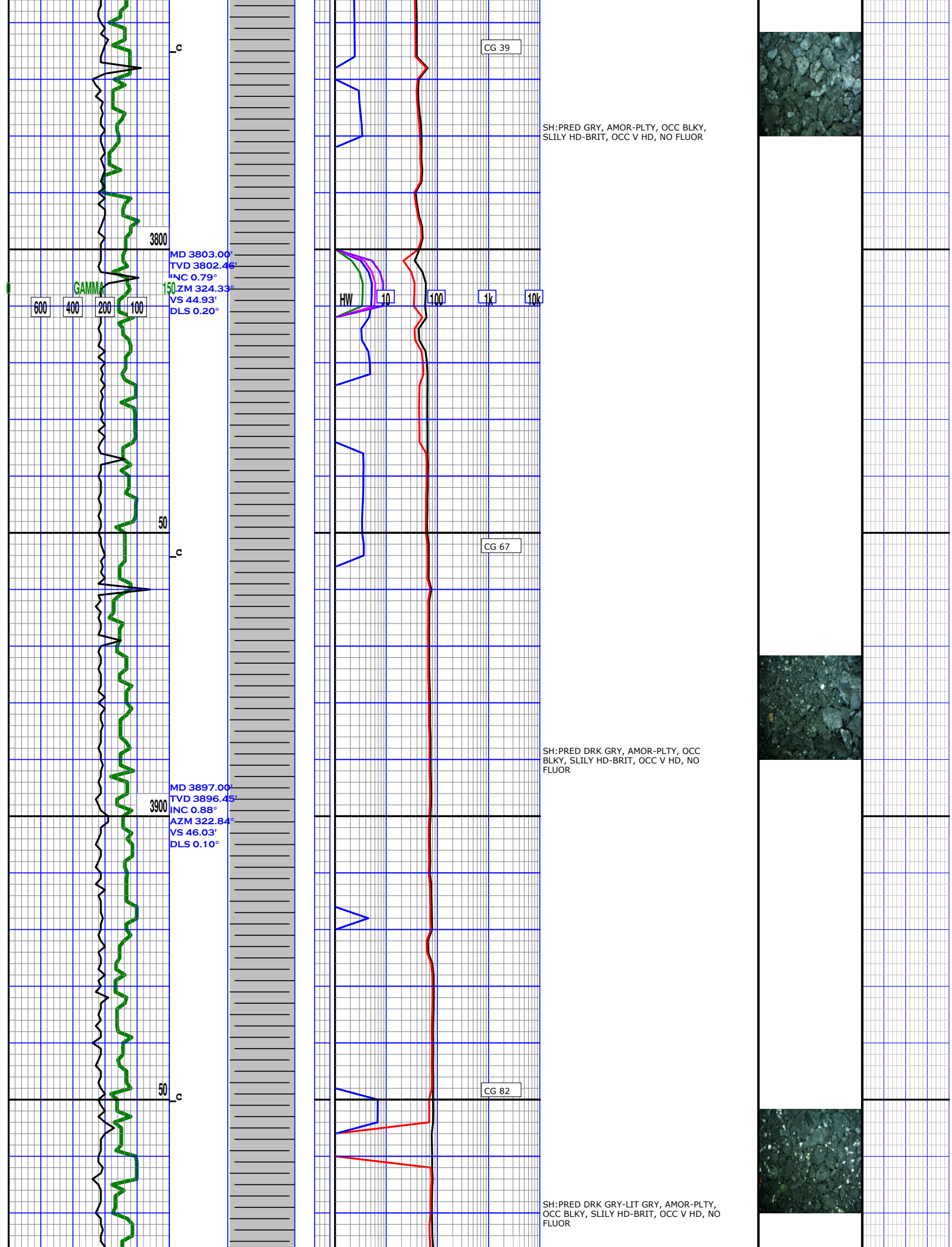
CG 88

HW 10 100 1k 10k

CG 21

SH:PRED MED-DK GRY, AMOR-PLTY, OCC BLKY, SLILY HD, SLTY TEX, NO FLUOR




3800
MD 3803.00'
TVD 3802.46'
INC 0.79°
AZM 324.33°
VS 44.93'
DLS 0.20°
GAMMA
150
600
400
200
100
50
HW
10
100
1k
10k
CG 39
SH:PRED GRY, AMOR-PLTY, OCC BLKY, SLILY HD-BRIT, OCC V HD, NO FLUOR
CG 67
3900
MD 3897.00'
TVD 3896.45'
INC 0.88°
AZM 322.84°
VS 46.03'
DLS 0.10°
SH:PRED DRK GRY, AMOR-PLTY, OCC BLKY, SLILY HD-BRIT, OCC V HD, NO FLUOR
CG 82
SH:PRED DRK GRY-LIT GRY, AMOR-PLTY, OCC BLKY, SLILY HD-BRIT, OCC V HD, NO FLUOR

MD 3992.00'
TVD 3991.44'
INC 1.01°
AZM 330.92°
VS 47.34'
DLS 0.20°

4000

GAMMA 150

600 400 200 100

HW 10 100 1k 10k

50

CG 96

MD 4086.00'
TVD 4085.43'
INC 0.75°
AZM 350.00°
VS 48.67'
DLS 0.41°

4100



SH:PRED DRK GRY, AMOR-PLTY, SUB BLKY- BLKY, SLILY HD-BRIT, OCC V HD, NO FLUOR

CG 112

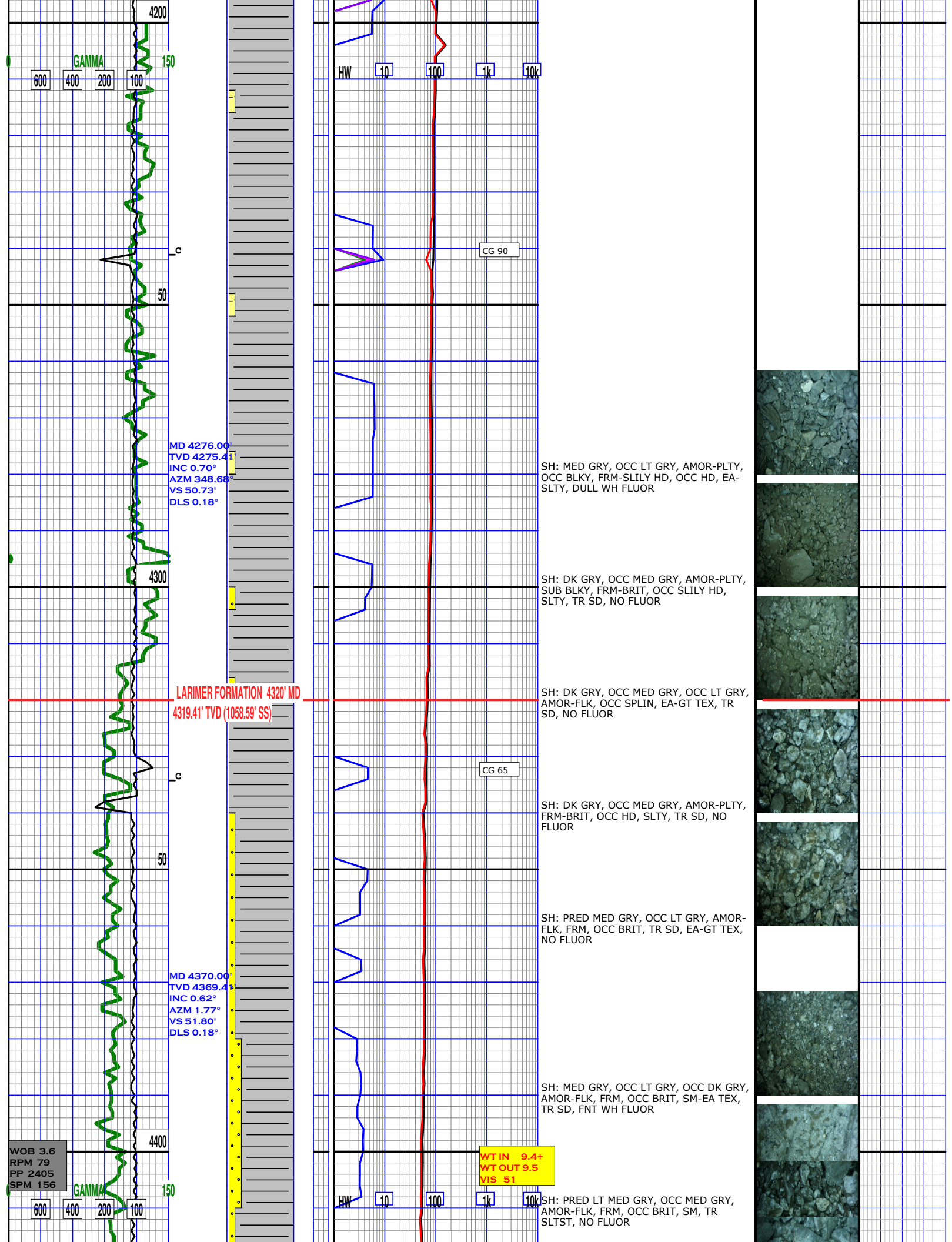
50

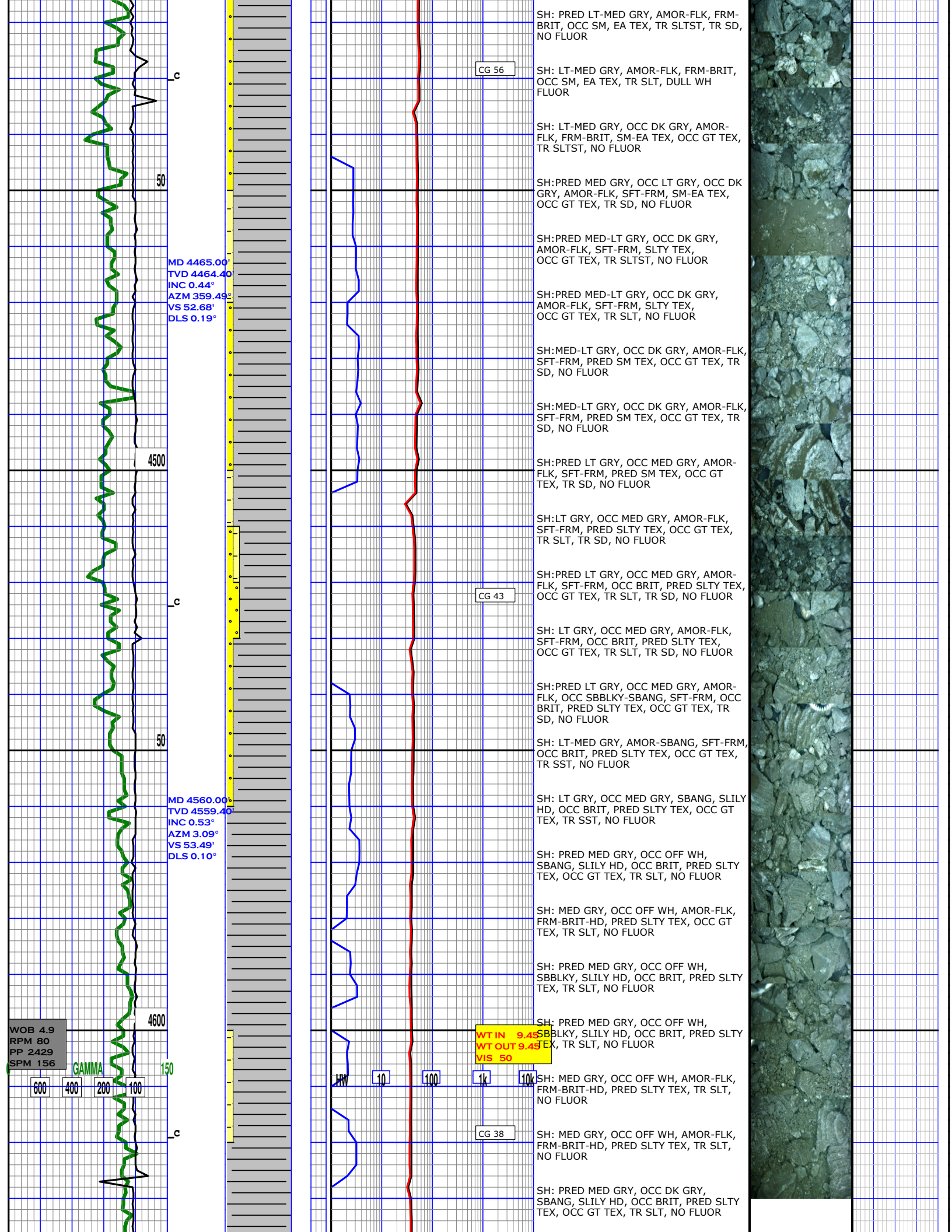
T.H

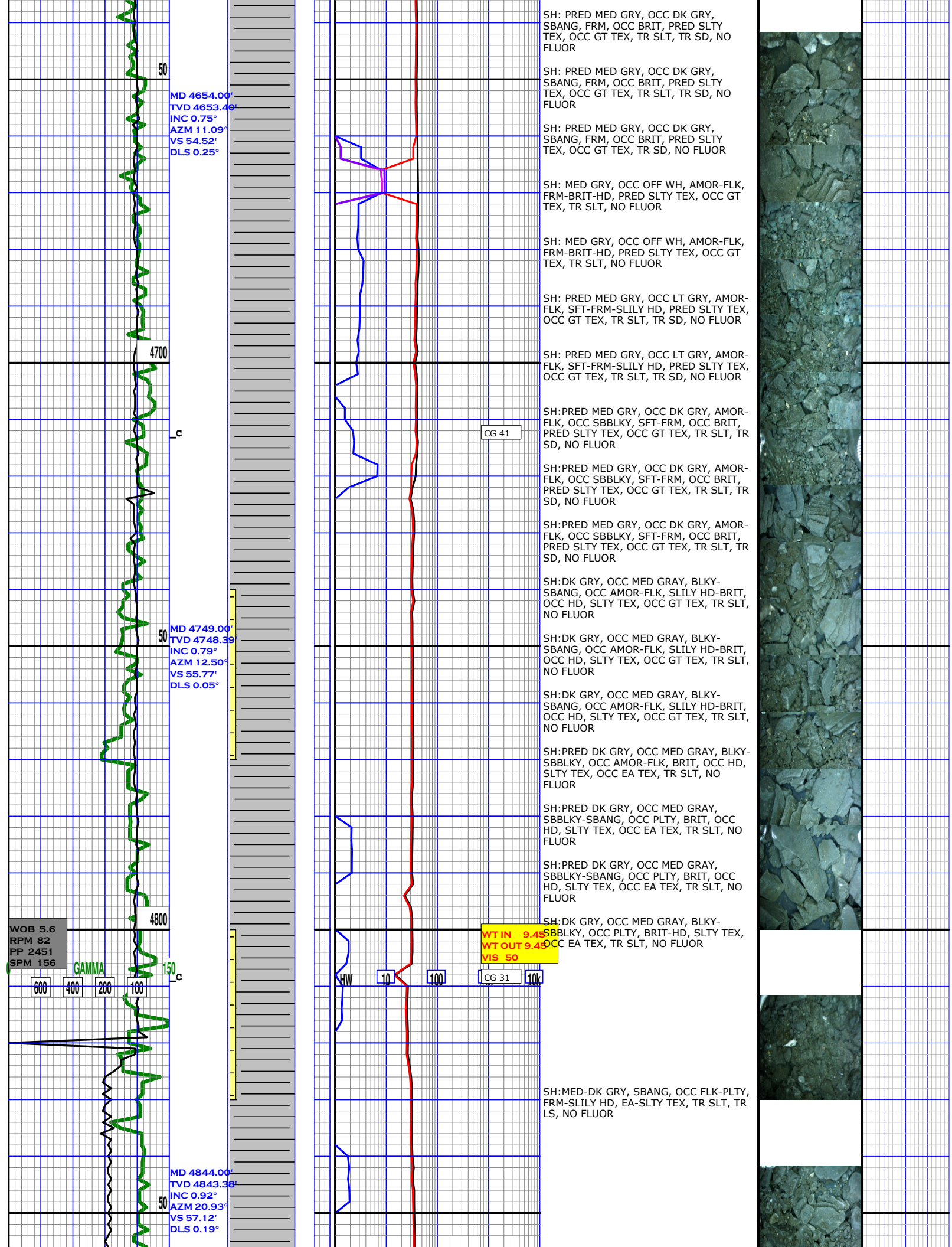
MD 4181.00'
TVD 4180.42'
INC 0.57°
AZM 338.22°
VS 49.72'
DLS 0.24°



SH:PRED DRK GRY, AMOR-PLTY, SUB BLKY- BLKY OCC MECH, HD-BRIT, OCC V HD, NO FLUOR


4200
GAMMA
600
400
200
100
150
50
4300
4400
HW
10
100
1k
10k
CG 90
CG 65
MD 4276.00'
TVD 4275.41
INC 0.70°
AZM 348.68°
VS 50.73'
DLS 0.18°
LARIMER FORMATION 4320' MD
4319.41' TVD (1058.59' SS)
MD 4370.00'
TVD 4369.41
INC 0.62°
AZM 1.77°
VS 51.80'
DLS 0.18°
WOB 3.6
RPM 79
PP 2405
SPM 156
WT IN 9.4+
WT OUT 9.5
VIS 51
SH: MED GRY, OCC LT GRY, AMOR-PLTY, OCC BLKY, FRM-SLILY HD, OCC HD, EA-SLTY, DULL WH FLUOR
SH: DK GRY, OCC MED GRY, AMOR-PLTY, SUB BLKY, FRM-BRIT, OCC SLILY HD, SLTY, TR SD, NO FLUOR
SH: DK GRY, OCC MED GRY, OCC LT GRY, AMOR-FLK, OCC SPLIN, EA-GT TEX, TR SD, NO FLUOR
SH: DK GRY, OCC MED GRY, AMOR-PLTY, FRM-BRIT, OCC HD, SLTY, TR SD, NO FLUOR
SH: PRED MED GRY, OCC LT GRY, AMOR-FLK, FRM, OCC BRIT, TR SD, EA-GT TEX, NO FLUOR
SH: MED GRY, OCC LT GRY, OCC DK GRY, AMOR-FLK, FRM, OCC BRIT, SM-EA TEX, TR SD, FNT WH FLUOR
SH: PRED LT MED GRY, OCC MED GRY, AMOR-FLK, FRM, OCC BRIT, SM, TR SLTST, NO FLUOR


SH: PRED LT-MED GRY, AMOR-FLK, FRM-BRIT, OCC SM, EA TEX, TR SLTST, TR SD, NO FLUOR
CG 56
SH: LT-MED GRY, AMOR-FLK, FRM-BRIT, OCC SM, EA TEX, TR SLT, DULL WH FLUOR
SH: LT-MED GRY, OCC DK GRY, AMOR-FLK, FRM-BRIT, SM-EA TEX, OCC GT TEX, TR SLTST, NO FLUOR
SH:PRED MED GRY, OCC LT GRY, OCC DK GRY, AMOR-FLK, SFT-FRM, SM-EA TEX, OCC GT TEX, TR SD, NO FLUOR
SH:PRED MED-LT GRY, OCC DK GRY, AMOR-FLK, SFT-FRM, SLTY TEX, OCC GT TEX, TR SLTST, NO FLUOR
SH:PRED MED-LT GRY, OCC DK GRY, AMOR-FLK, SFT-FRM, SLTY TEX, OCC GT TEX, TR SLT, NO FLUOR
SH:MED-LT GRY, OCC DK GRY, AMOR-FLK, SFT-FRM, PRED SM TEX, OCC GT TEX, TR SD, NO FLUOR
SH:MED-LT GRY, OCC DK GRY, AMOR-FLK, SFT-FRM, PRED SM TEX, OCC GT TEX, TR SD, NO FLUOR
SH:PRED LT GRY, OCC MED GRY, AMOR-FLK, SFT-FRM, PRED SM TEX, OCC GT TEX, TR SD, NO FLUOR
SH:LT GRY, OCC MED GRY, AMOR-FLK, SFT-FRM, PRED SLTY TEX, OCC GT TEX, TR SLT, TR SD, NO FLUOR
CG 43
SH:PRED LT GRY, OCC MED GRY, AMOR-FLK, SFT-FRM, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SLT, TR SD, NO FLUOR
SH: LT GRY, OCC MED GRY, AMOR-FLK, SFT-FRM, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SLT, TR SD, NO FLUOR
SH:PRED LT GRY, OCC MED GRY, AMOR-FLK, OCC SBBLKY-SBANG, SFT-FRM, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SD, NO FLUOR
SH: LT-MED GRY, AMOR-SBANG, SFT-FRM, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SST, NO FLUOR
SH: LT GRY, OCC MED GRY, SBANG, SLILY HD, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SST, NO FLUOR
SH: PRED MED GRY, OCC OFF WH, SBANG, SLILY HD, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SLT, NO FLUOR
SH: MED GRY, OCC OFF WH, AMOR-FLK, FRM-BRIT-HD, PRED SLTY TEX, OCC GT TEX, TR SLT, NO FLUOR
SH: PRED MED GRY, OCC OFF WH, SBBLKY, SLILY HD, OCC BRIT, PRED SLTY TEX, TR SLT, NO FLUOR
SH: PRED MED GRY, OCC OFF WH, SBBLKY, SLILY HD, OCC BRIT, PRED SLTY TEX, TR SLT, NO FLUOR
WT IN 9.45
WT OUT 9.45
VIS 50
SH: MED GRY, OCC OFF WH, AMOR-FLK, FRM-BRIT-HD, PRED SLTY TEX, TR SLT, NO FLUOR
CG 38
SH: MED GRY, OCC OFF WH, AMOR-FLK, FRM-BRIT-HD, PRED SLTY TEX, TR SLT, NO FLUOR
SH: PRED MED GRY, OCC DK GRY, SBANG, SLILY HD, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SLT, NO FLUOR
MD 4465.00'
TVD 4464.40'
INC 0.44°
AZM 359.49°
VS 52.68'
DLS 0.19°
MD 4560.00'
TVD 4559.40'
INC 0.53°
AZM 3.09°
VS 53.49'
DLS 0.10°
50
4500
50
4600
WOB 4.9
RPM 80
PP 2429
SPM 156
GAMMA
600
400
200
100
150
HW
10
100
1k
10k


50
MD 4654.00'
TVD 4653.49'
INC 0.75°
AZM 11.09°
VS 54.52'
DLS 0.25°
4700
MD 4749.00'
TVD 4748.39'
INC 0.79°
AZM 12.50°
VS 55.77'
DLS 0.05°
50
4800
WOB 5.6
RPM 82
PP 2451
SPM 156
GAMMA
600
400
200
100
150
MD 4844.00'
TVD 4843.38'
INC 0.92°
AZM 20.93°
VS 57.12'
DLS 0.19°
50
CG 41
WT IN 9.45
WT OUT 9.45
VIS 50
HW
10
100
CG 31
10k
SH: PRED MED GRY, OCC DK GRY, SBANG, FRM, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SLT, TR SD, NO FLUOR
SH: PRED MED GRY, OCC DK GRY, SBANG, FRM, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SLT, TR SD, NO FLUOR
SH: PRED MED GRY, OCC DK GRY, SBANG, FRM, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SD, NO FLUOR
SH: MED GRY, OCC OFF WH, AMOR-FLK, FRM-BRIT-HD, PRED SLTY TEX, OCC GT TEX, TR SLT, NO FLUOR
SH: MED GRY, OCC OFF WH, AMOR-FLK, FRM-BRIT-HD, PRED SLTY TEX, OCC GT TEX, TR SLT, NO FLUOR
SH: PRED MED GRY, OCC LT GRY, AMOR-FLK, SFT-FRM-SLILY HD, PRED SLTY TEX, OCC GT TEX, TR SLT, TR SD, NO FLUOR
SH: PRED MED GRY, OCC LT GRY, AMOR-FLK, SFT-FRM-SLILY HD, PRED SLTY TEX, OCC GT TEX, TR SLT, TR SD, NO FLUOR
SH:PRED MED GRY, OCC DK GRY, AMOR-FLK, OCC SBBLKY, SFT-FRM, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SLT, TR SD, NO FLUOR
SH:PRED MED GRY, OCC DK GRY, AMOR-FLK, OCC SBBLKY, SFT-FRM, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SLT, TR SD, NO FLUOR
SH:PRED MED GRY, OCC DK GRY, AMOR-FLK, OCC SBBLKY, SFT-FRM, OCC BRIT, PRED SLTY TEX, OCC GT TEX, TR SLT, TR SD, NO FLUOR
SH:DK GRY, OCC MED GRAY, BLKY-SBANG, OCC AMOR-FLK, SLILY HD-BRIT, OCC HD, SLTY TEX, OCC GT TEX, TR SLT, NO FLUOR
SH:DK GRY, OCC MED GRAY, BLKY-SBANG, OCC AMOR-FLK, SLILY HD-BRIT, OCC HD, SLTY TEX, OCC GT TEX, TR SLT, NO FLUOR
SH:DK GRY, OCC MED GRAY, BLKY-SBANG, OCC AMOR-FLK, SLILY HD-BRIT, OCC HD, SLTY TEX, OCC GT TEX, TR SLT, NO FLUOR
SH:PRED DK GRY, OCC MED GRAY, BLKY-SBBLKY, OCC AMOR-FLK, BRIT, OCC HD, SLTY TEX, OCC EA TEX, TR SLT, NO FLUOR
SH:PRED DK GRY, OCC MED GRAY, SBBLKY-SBANG, OCC PLTY, BRIT, OCC HD, SLTY TEX, OCC EA TEX, TR SLT, NO FLUOR
SH:PRED DK GRY, OCC MED GRAY, SBBLKY-SBANG, OCC PLTY, BRIT, OCC HD, SLTY TEX, OCC EA TEX, TR SLT, NO FLUOR
SH:DK GRY, OCC MED GRAY, BLKY-SBBLKY, OCC PLTY, BRIT-HD, SLTY TEX, OCC EA TEX, TR SLT, NO FLUOR
SH:MED-DK GRY, SBANG, OCC FLK-PLTY, FRM-SLILY HD, EA-SLTY TEX, TR SLT, TR LS, NO FLUOR

SH:MED-DK GRY, SBANG-SBBLKY, OCC FLK-PLTY, SLILY HD-HD, EA-SLTY TEX, TR SLT, NO FLUOR



SH: PRED MED-DK GRY, SBBLKY-BLKY, OCC FLK-PLTY, SLILY HD-HD, EA-SLTY TEX, TR SLT, NO FLUOR



SH: PRED DK GRY, OCC V DK GRY, SBBLKY-BLKY, OCC SBANG, OCC FLK-PLTY, SLILY HD-HD, EA-SLTY TEX, TR SLT, NO FLUOR



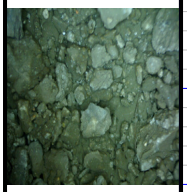
SH: DK GRY, OCC V DK GRY, SBBLKY-BLKY, OCC SBANG, OCC FLK-PLTY, BRIT-HD, EA-SLTY TEX, TR SLT, NO FLUOR



SH: DK GRY, OCC V DK GRY, SBBLKY-SBANG, OCC SPLIN, OCC FLK-PLTY, BRIT-HD, EA-SLTY TEX, NO FLUOR



SH: PRED MED GRY, OCC DK GRY, SBANG, OCC SPLIN, OCC AMOR, BRIT-SLILY HD, EA-GT TEX, NO FLUOR



SH: MED GRY, OCC LT GRY, AMOR, OCC SBANG, BRIT-SLILY HD, EA-GT TEX, NO FLUOR



SH: MED GRY, OCC LT GRY, SBBLKY-AMOR, OCC SBANG, BRIT-SLILY HD, EA-GT TEX, NO FLUOR

4900

50

SUSSEX FORMATION 4927' MD
4926.36' TVD (451.64' SS)

MD 4938.00'
TVD 4937.36'
INC 1.14°
AZM 27.88°
VS 58.66'
DLS 0.27°

5000

50

MD 5033.00'
TVD 5032.34'
INC 1.20°
AZM 31.20°
VS 60.30'
DLS 0.09°

CG 39

CG 41

WT IN 9.5
WT OUT 9.5
VIS 51

WOB 3.8
RPM 51
PP 2421
SPM 156

GAMMA 150
600 400 200 100

HW 10 100 1k 10k

5100

MD 5128.00'
TVD 5127.32'
INC 1.14°
AZM 24.71°
VS 62.04'
DLS 0.15°

50

5200

WOB 5.4
RPM 83
PP 2716
SPM 158

GAMMA 150

600 400 200 100

MD 5222.00'
TVD 5221.30'
INC 1.05°
AZM 23.39°
VS 63.68'
DLS 0.10°

50

CG 45

CG 42

WT IN 9.5
WT OUT 9.5
VIS 5

HW 10 100 1k 10k

CG 54

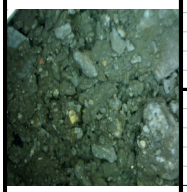
SH: MED GRY, OCC DK GRY, AMOR, OCC SBANG, BRIT-SLILY HD, EA-GT TEX, NO FLUOR



SH: PRED MED GRY, OCC DK GRY, AMOR, OCC SBANG, BRIT- HD, EA-GT TEX, NO FLUOR



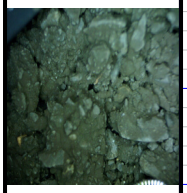
SH: MED GRY, OCC DK GRY, AMOR, OCC PLTY, BRIT- HD, SLTY-EA TEX, TR SST, NO FLUOR



SH: PRED MED GRY, OCC DK GRY, SBANG-AMOR, OCC PLTY, OCC FLK, BRIT-HD, SLTY-EA TEX, TR SST, TR SLT, NO FLUOR



SH: PRED MED GRY, OCC DK GRY, SBANG-SBBLKY, PLTY, OCC FLK, SLILY HD- HD, SLTY-EA TEX, TR SLT, NO FLUOR



SH: MED GRY-DK GRY, AMOR-SBANG, OCC PLTY, BRIT, EA-SLTY TEX, TR SLT, NO FLUOR



SH: PRED MED GRY-DK GRY, AMOR, OCC SBBLKY-BLKY, OCC PLTY, SLILY HD-BRIT, EA-SLTY TEX, TR SLT, NO FLUOR

5300

MD 5317.00'
TVD 5316.29'
INC 0.97°
AZM 26.91°
VS 65.19'
DLS 0.11°

50

H.A

SHANNON FORMATION 5372' MD
5371.28' TVD ( 6.72' SS)

C

5400

WOB 8.0
RPM 79
PP 2731
SPM 157

GAMMA 150
600 400 200 100

MD 5412.00'
TVD 5411.28'
INC 1.01°
AZM 11.70°
VS 66.64'
DLS 0.00°

50

T.H

C

5500

MD 5506.00'
TVD 5505.26'
INC 1.05°
AZM 15.92°
VS 68.28'
DLS 0.09°

CG 51

WT IN 9.45
WT OUT 9.45
VIS 49

HW 10 100 1k 10k

CG 45

SH: MED GRY- V DK GRY, AMOR-SBANG-SBBLKY, SLILY HD-BRIT, SLTY TEX, TR SLT, NO FLUOR





SH: PRED MED GRY-DK GRY, AMOR, OCC SBBLKY-BLKY, OCC PLTY, SLILY HD-BRIT, EA-SLTY TEX, TR SLT, NO FLUOR



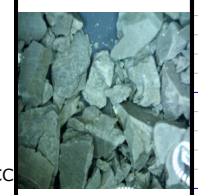
SH: PRED MED GRY-DK GRY, AMOR, OCC SBBLKY, OCC PLTY, SLILY HD EA-SLTY TEX, TR SLT, NO FLUOR



SH: PRED MED GRY, AMOR, OCC SBBLKY, OCC PLTY, SLILY HD EA-SLTY TEX, TR SLT, NO FLUOR



SH: PRED MED GRY-DK GRY, SBBLKY-BLKY, OCC PLTY, SLILY HD EA-SLTY TEX, TR SLT, NO FLUOR

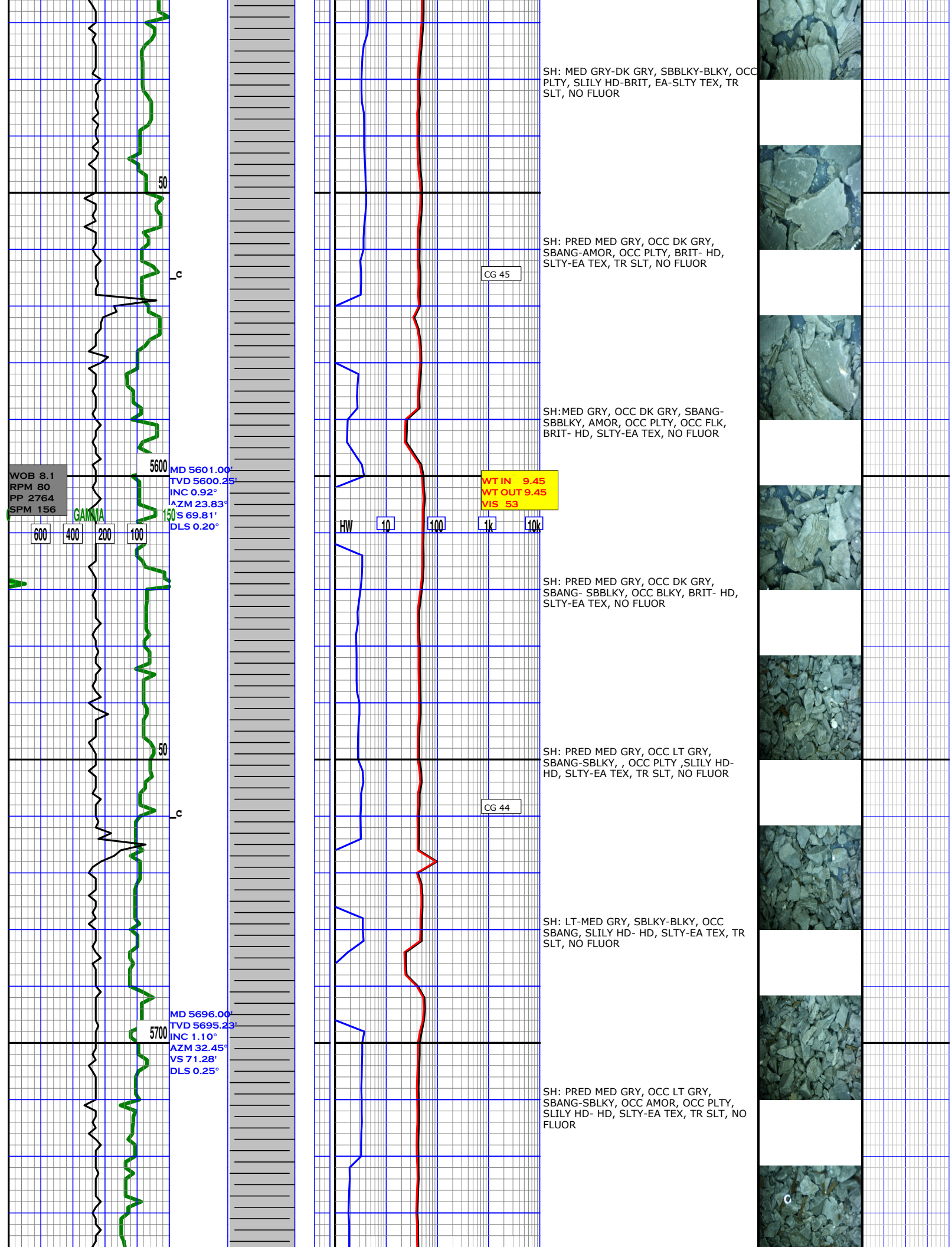


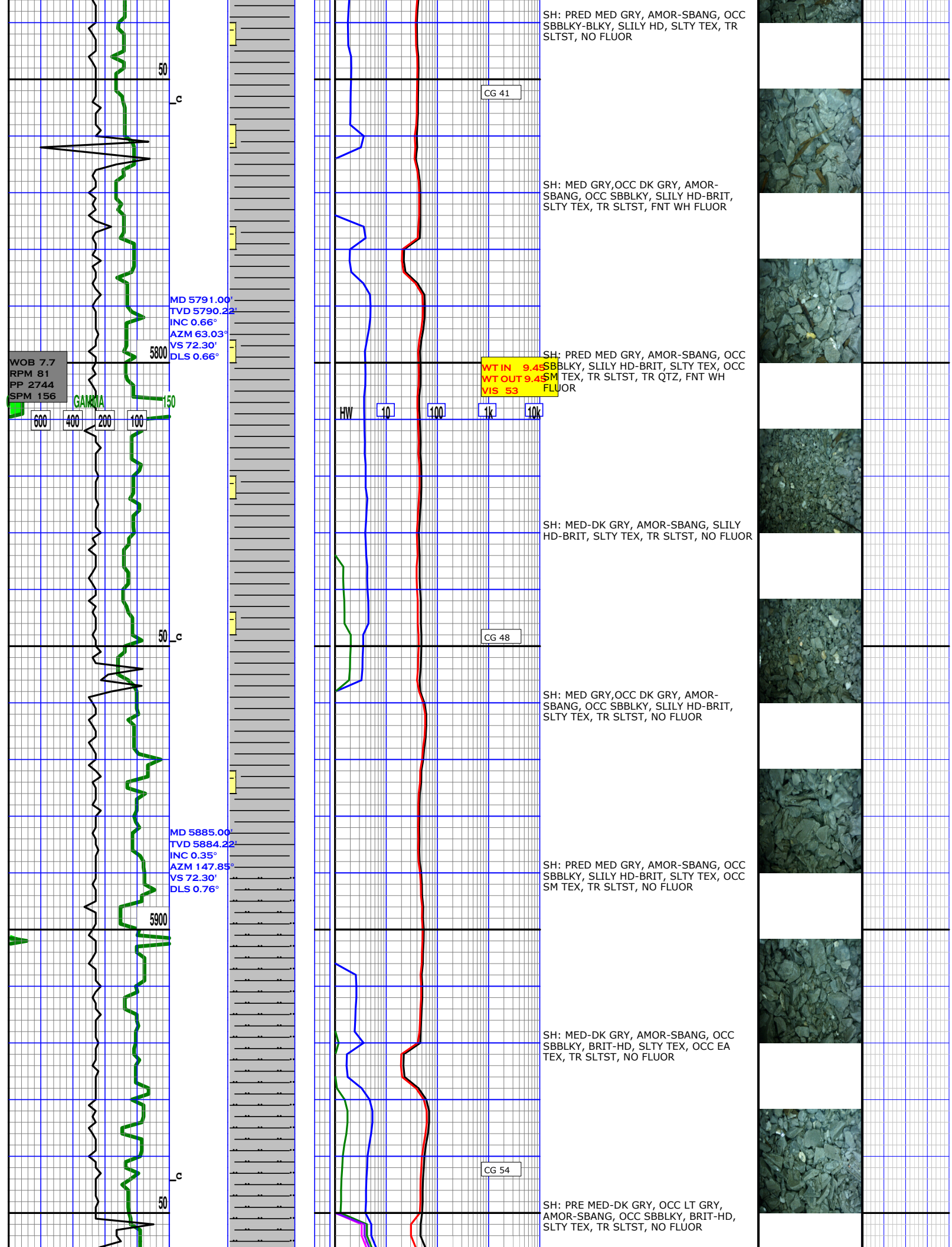
SH: MED GRY-DK GRY, SBBLKY-BLKY, OCC PLTY, SLILY HD-BRIT, EA-SLTY TEX, TR SLT, NO FLUOR

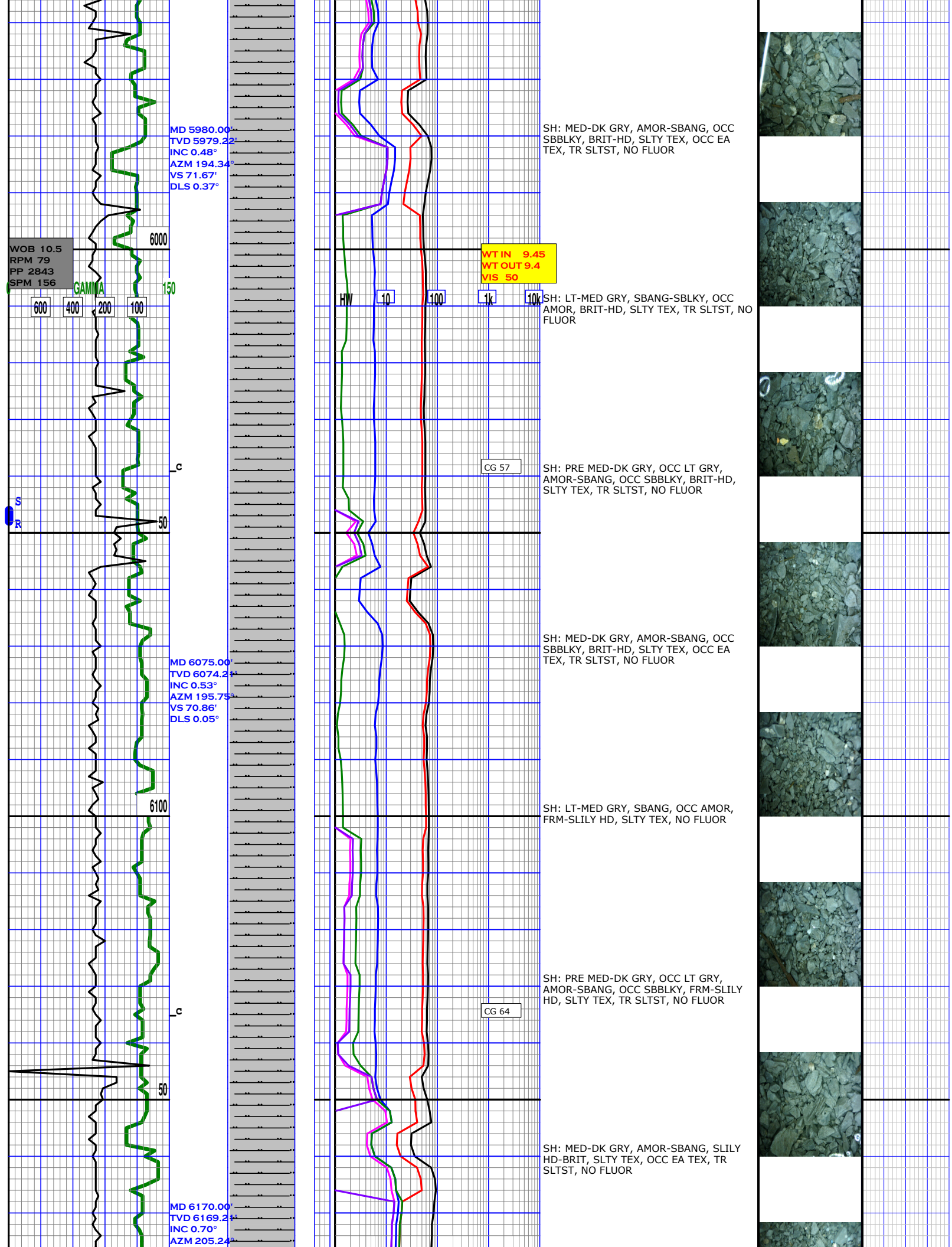


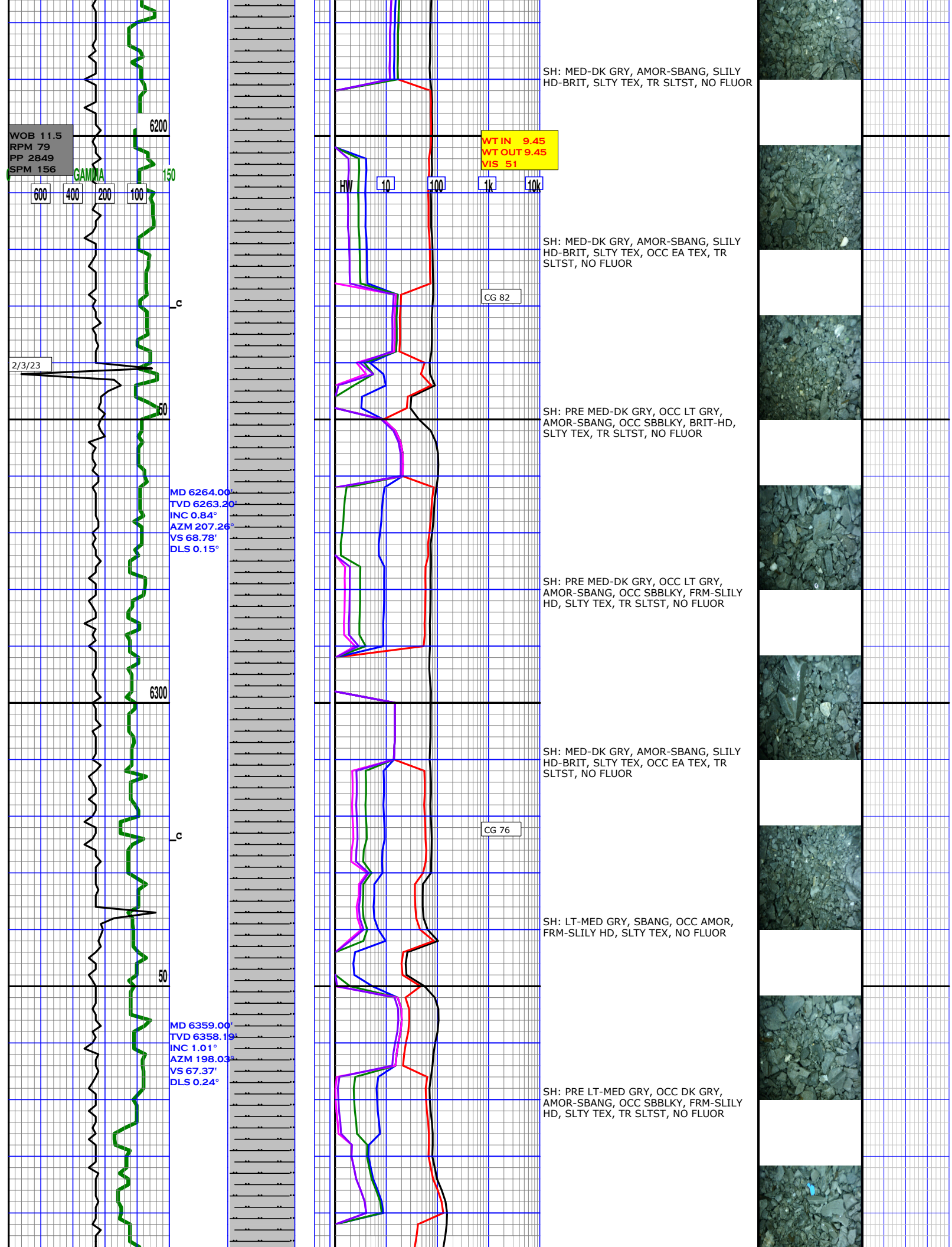
SH: PRED MED GRY, OCC DK GRY, SBANG-AMOR, OCC PLTY, BRIT- HD, SLTY-EA TEX, TR SLT, NO FLUOR

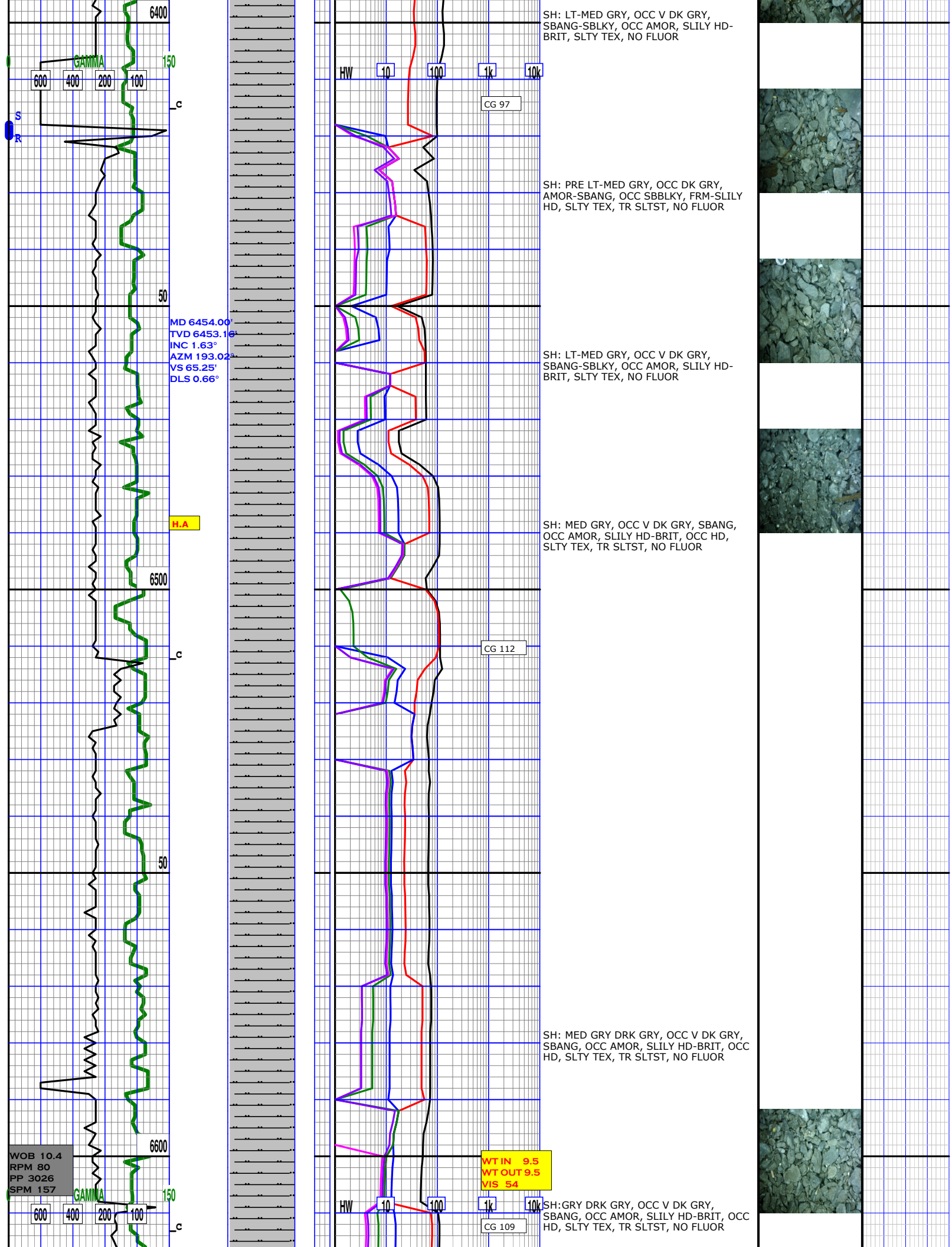



50
C
5600
MD 5601.00'
TVD 5600.25'
INC 0.92°
AZM 23.83°
VS 69.81'
DLS 0.20°
WOB 8.1
RPM 80
PP 2764
SPM 156
GAMMA
150
600
400
200
100
HW
10
100
1k
10k
WT IN 9.45
WT OUT 9.45
VIS 53
CG 45
CG 44
50
C
5700
MD 5696.00'
TVD 5695.23'
INC 1.10°
AZM 32.45°
VS 71.28'
DLS 0.25°
SH: MED GRY-DK GRY, SBBLKY-BLKY, OCC PLTY, SLILY HD-BRIT, EA-SLTY TEX, TR SLT, NO FLUOR
SH: PRED MED GRY, OCC DK GRY, SBANG-AMOR, OCC PLTY, BRIT- HD, SLTY-EA TEX, TR SLT, NO FLUOR
SH:MED GRY, OCC DK GRY, SBANG-SBBLKY, AMOR, OCC PLTY, OCC FLK, BRIT- HD, SLTY-EA TEX, NO FLUOR
SH: PRED MED GRY, OCC DK GRY, SBANG- SBBLKY, OCC BLKY, BRIT- HD, SLTY-EA TEX, NO FLUOR
SH: PRED MED GRY, OCC LT GRY, SBANG-SBLKY, , OCC PLTY ,SLILY HD-HD, SLTY-EA TEX, TR SLT, NO FLUOR
SH: LT-MED GRY, SBLKY-BLKY, OCC SBANG, SLILY HD- HD, SLTY-EA TEX, TR SLT, NO FLUOR
SH: PRED MED GRY, OCC LT GRY, SBANG-SBLKY, OCC AMOR, OCC PLTY, SLILY HD- HD, SLTY-EA TEX, TR SLT, NO FLUOR


50
C
MD 5791.00'
TVD 5790.22'
INC 0.66°
AZM 63.03°
VS 72.30'
DLS 0.66°
5800
WOB 7.7
RPM 81
PP 2744
SPM 156
GAMMA
600
400
200
100
150
50
C
MD 5885.00'
TVD 5884.22'
INC 0.35°
AZM 147.85°
VS 72.30'
DLS 0.76°
5900
50
C
HW
10
100
1k
10k
CG 41
CG 48
CG 54
WT IN 9.45
WT OUT 9.45
VIS 53
SH: PRED MED GRY, AMOR-SBANG, OCC SBBLKY-BLKY, SLILY HD, SLTY TEX, TR SLTST, NO FLUOR
SH: MED GRY,OCC DK GRY, AMOR-SBANG, OCC SBBLKY, SLILY HD-BRIT, SLTY TEX, TR SLTST, FNT WH FLUOR
SH: PRED MED GRY, AMOR-SBANG, OCC SBBLKY, SLILY HD-BRIT, SLTY TEX, OCC SM TEX, TR SLTST, TR QTZ, FNT WH FLUOR
SH: MED-DK GRY, AMOR-SBANG, SLILY HD-BRIT, SLTY TEX, TR SLTST, NO FLUOR
SH: MED GRY,OCC DK GRY, AMOR-SBANG, OCC SBBLKY, SLILY HD-BRIT, SLTY TEX, TR SLTST, NO FLUOR
SH: PRED MED GRY, AMOR-SBANG, OCC SBBLKY, SLILY HD-BRIT, SLTY TEX, OCC SM TEX, TR SLTST, NO FLUOR
SH: MED-DK GRY, AMOR-SBANG, OCC SBBLKY, BRIT-HD, SLTY TEX, OCC EA TEX, TR SLTST, NO FLUOR
SH: PRE MED-DK GRY, OCC LT GRY, AMOR-SBANG, OCC SBBLKY, BRIT-HD, SLTY TEX, TR SLTST, NO FLUOR


MD 5980.00'
TVD 5979.22'
INC 0.48°
AZM 194.34°
VS 71.67'
DLS 0.37°
WOB 10.5
RPM 79
PP 2843
SPM 156
GAMMA
600
400
200
100
150
6000
50
WT IN 9.45
WT OUT 9.4
VIS 50
HW
10
100
1k
10k
CG 57
SH: MED-DK GRY, AMOR-SBANG, OCC SBBLKY, BRIT-HD, SLTY TEX, OCC EA TEX, TR SLTST, NO FLUOR
SH: LT-MED GRY, SBANG-SBLKY, OCC AMOR, BRIT-HD, SLTY TEX, TR SLTST, NO FLUOR
SH: PRE MED-DK GRY, OCC LT GRY, AMOR-SBANG, OCC SBBLKY, BRIT-HD, SLTY TEX, TR SLTST, NO FLUOR
MD 6075.00'
TVD 6074.21'
INC 0.53°
AZM 195.75°
VS 70.86'
DLS 0.05°
6100
SH: MED-DK GRY, AMOR-SBANG, OCC SBBLKY, BRIT-HD, SLTY TEX, OCC EA TEX, TR SLTST, NO FLUOR
SH: LT-MED GRY, SBANG, OCC AMOR, FRM-SLILY HD, SLTY TEX, NO FLUOR
CG 64
SH: PRE MED-DK GRY, OCC LT GRY, AMOR-SBANG, OCC SBBLKY, FRM-SLILY HD, SLTY TEX, TR SLTST, NO FLUOR
SH: MED-DK GRY, AMOR-SBANG, SLILY HD-BRIT, SLTY TEX, OCC EA TEX, TR SLTST, NO FLUOR
MD 6170.00'
TVD 6169.21'
INC 0.70°
AZM 205.24°


WOB 11.5
RPM 79
PP 2849
SPM 156
GAMMA
600
400
200
100
150
6200
6300
50
2/3/23
MD 6264.00'
TVD 6263.20'
INC 0.84°
AZM 207.26°
VS 68.78'
DLS 0.15°
MD 6359.00'
TVD 6358.19'
INC 1.01°
AZM 198.03°
VS 67.37'
DLS 0.24°
HW
10
100
1k
10k
WT IN 9.45
WT OUT 9.45
VIS 51
CG 82
CG 76
SH: MED-DK GRY, AMOR-SBANG, SLILY HD-BRIT, SLTY TEX, TR SLTST, NO FLUOR
SH: MED-DK GRY, AMOR-SBANG, SLILY HD-BRIT, SLTY TEX, OCC EA TEX, TR SLTST, NO FLUOR
SH: PRE MED-DK GRY, OCC LT GRY, AMOR-SBANG, OCC SBBLKY, BRIT-HD, SLTY TEX, TR SLTST, NO FLUOR
SH: PRE MED-DK GRY, OCC LT GRY, AMOR-SBANG, OCC SBBLKY, FRM-SLILY HD, SLTY TEX, TR SLTST, NO FLUOR
SH: MED-DK GRY, AMOR-SBANG, SLILY HD-BRIT, SLTY TEX, OCC EA TEX, TR SLTST, NO FLUOR
SH: LT-MED GRY, SBANG, OCC AMOR, FRM-SLILY HD, SLTY TEX, NO FLUOR
SH: PRE LT-MED GRY, OCC DK GRY, AMOR-SBANG, OCC SBBLKY, FRM-SLILY HD, SLTY TEX, TR SLTST, NO FLUOR


6400
GAMMA
600
400
200
100
150
50
S
R
MD 6454.00'
TVD 6453.16'
INC 1.63°
AZM 193.02°
VS 65.25'
DLS 0.66°
H.A
6500
50
6600
WOB 10.4
RPM 80
PP 3026
SPM 157
GAMMA
600
400
200
100
150
HW
10
100
1k
10k
CG 97
CG 112
WT IN 9.5
WT OUT 9.5
VIS 54
CG 109
SH: LT-MED GRY, OCC V DK GRY, SBANG-SBLKY, OCC AMOR, SLILY HD-BRIT, SLTY TEX, NO FLUOR
SH: PRE LT-MED GRY, OCC DK GRY, AMOR-SBANG, OCC SBBLKY, FRM-SLILY HD, SLTY TEX, TR SLTST, NO FLUOR
SH: LT-MED GRY, OCC V DK GRY, SBANG-SBLKY, OCC AMOR, SLILY HD-BRIT, SLTY TEX, NO FLUOR
SH: MED GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD-BRIT, OCC HD, SLTY TEX, TR SLTST, NO FLUOR
SH: MED GRY DRK GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD-BRIT, OCC HD, SLTY TEX, TR SLTST, NO FLUOR
SH:GRY DRK GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD-BRIT, OCC HD, SLTY TEX, TR SLTST, NO FLUOR

MD 6643.00'
TVD 6642.10'
INC 1.54°
AZM 191.18°
VS 60.33'
DLS 0.13°

50

6700

C

MD 6738.00'
TVD 6737.06'
INC 1.71°
AZM 181.07°
VS 57.66'
DLS 0.35°

50

6800

C

WOB 1.8
RPM 57
PP 2566
SPM 156

GAMMA

600 400 200 100 150

MD 6833.00'
TVD 6832.02'
INC 1.67°

CG 69

CG 80

WT IN 9.5
WT OUT 9.4
VIS 56

HW 10 100 1k 10k

SH:DRK GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD-BRIT, OCC HD, SLTY TEX, TR SLTST, NO FLUOR



SH:DRK GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD, OCC HD, SLTY TEX, TR SLTST, NO FLUOR



SH:DRK GRY-LIT GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD, OCC HD, SLTY TEX, TR SLTST, NO FLUOR



SH:DRK GRY- GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD, OCC HD, SLTY TEX, TR SLTST, NO FLUOR

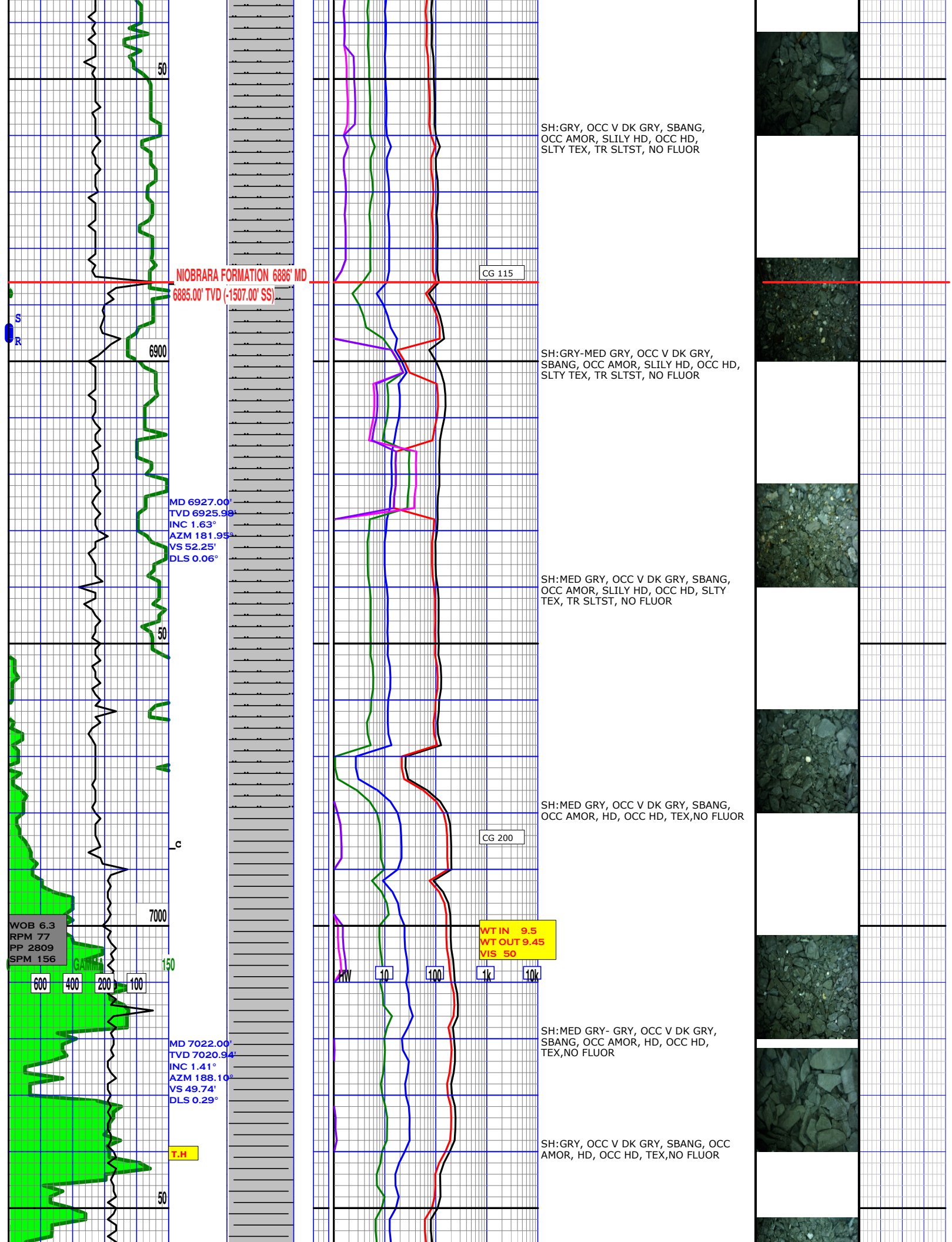


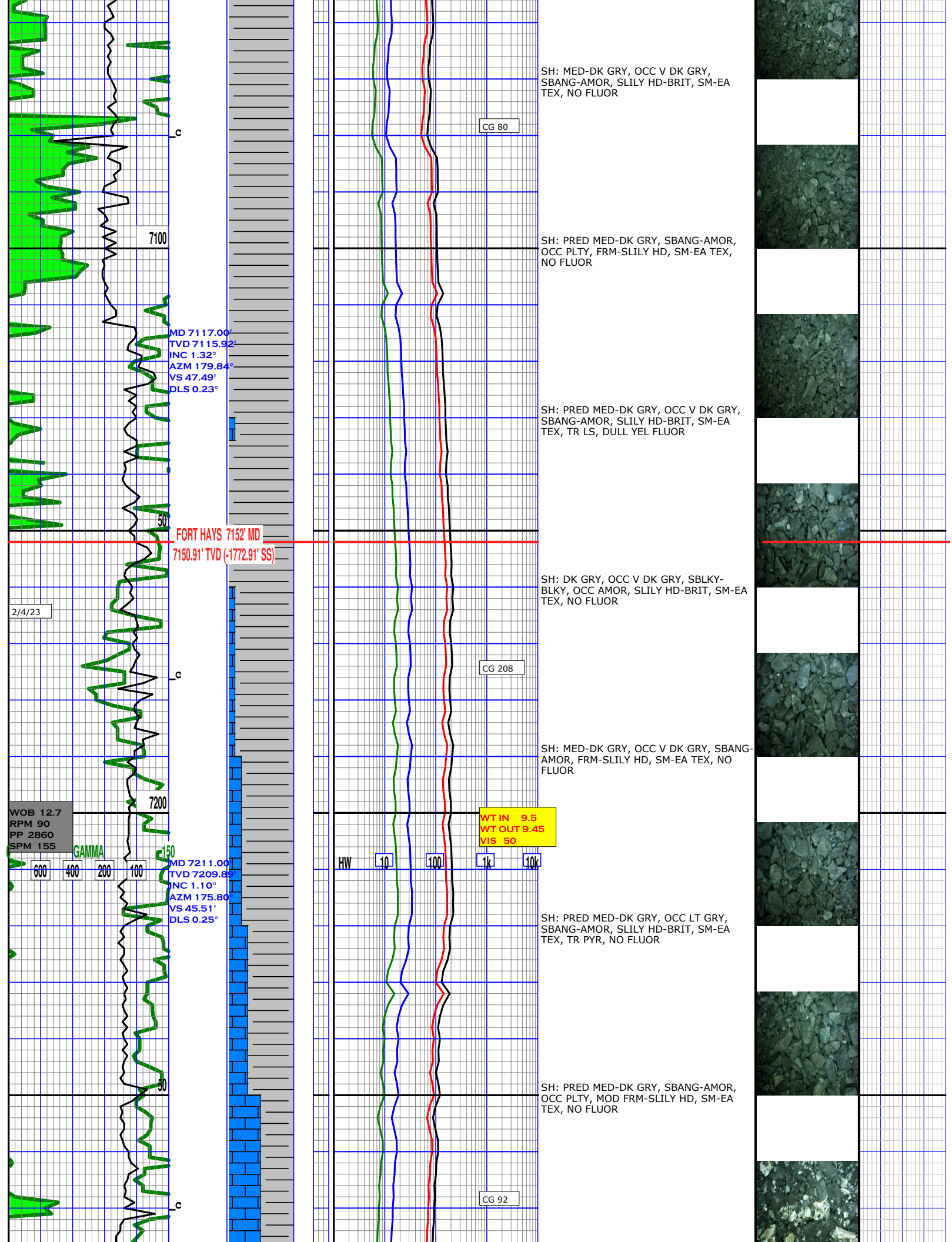
SH:DRK GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD, OCC HD, SLTY TEX, TR SLTST, NO FLUOR

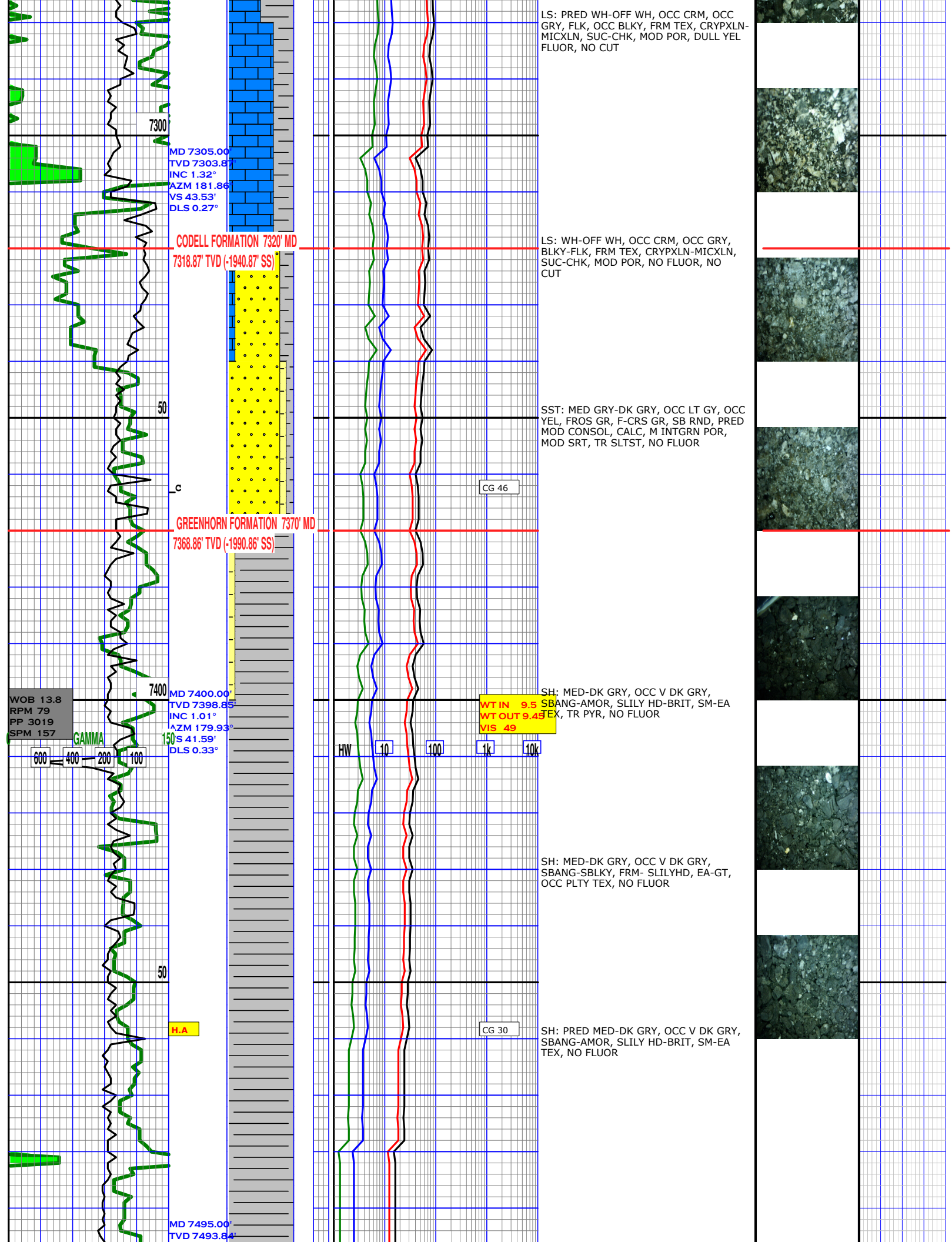


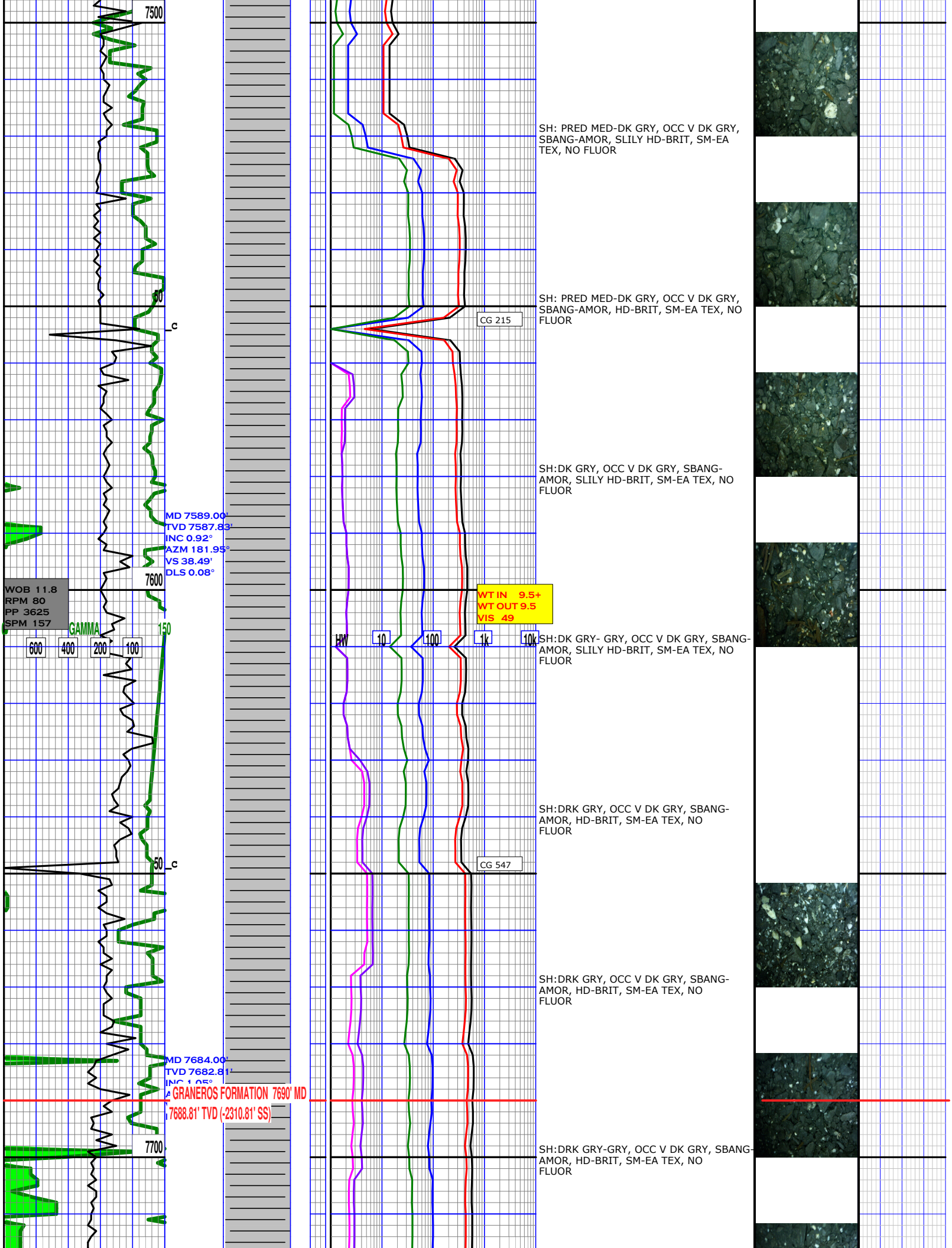
SH:DRK GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD, OCC HD, SLTY TEX, TR SLTST, NO FLUOR

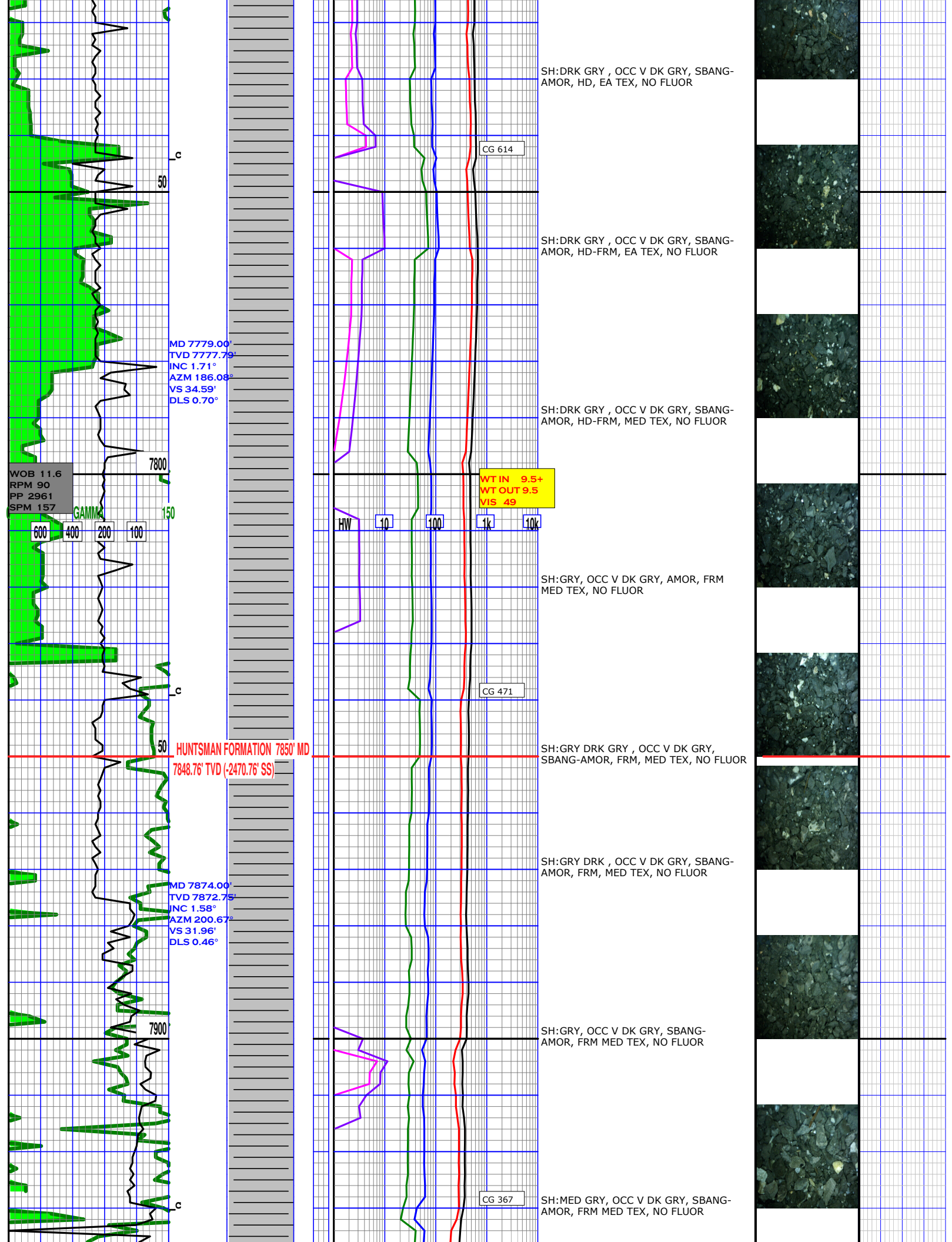


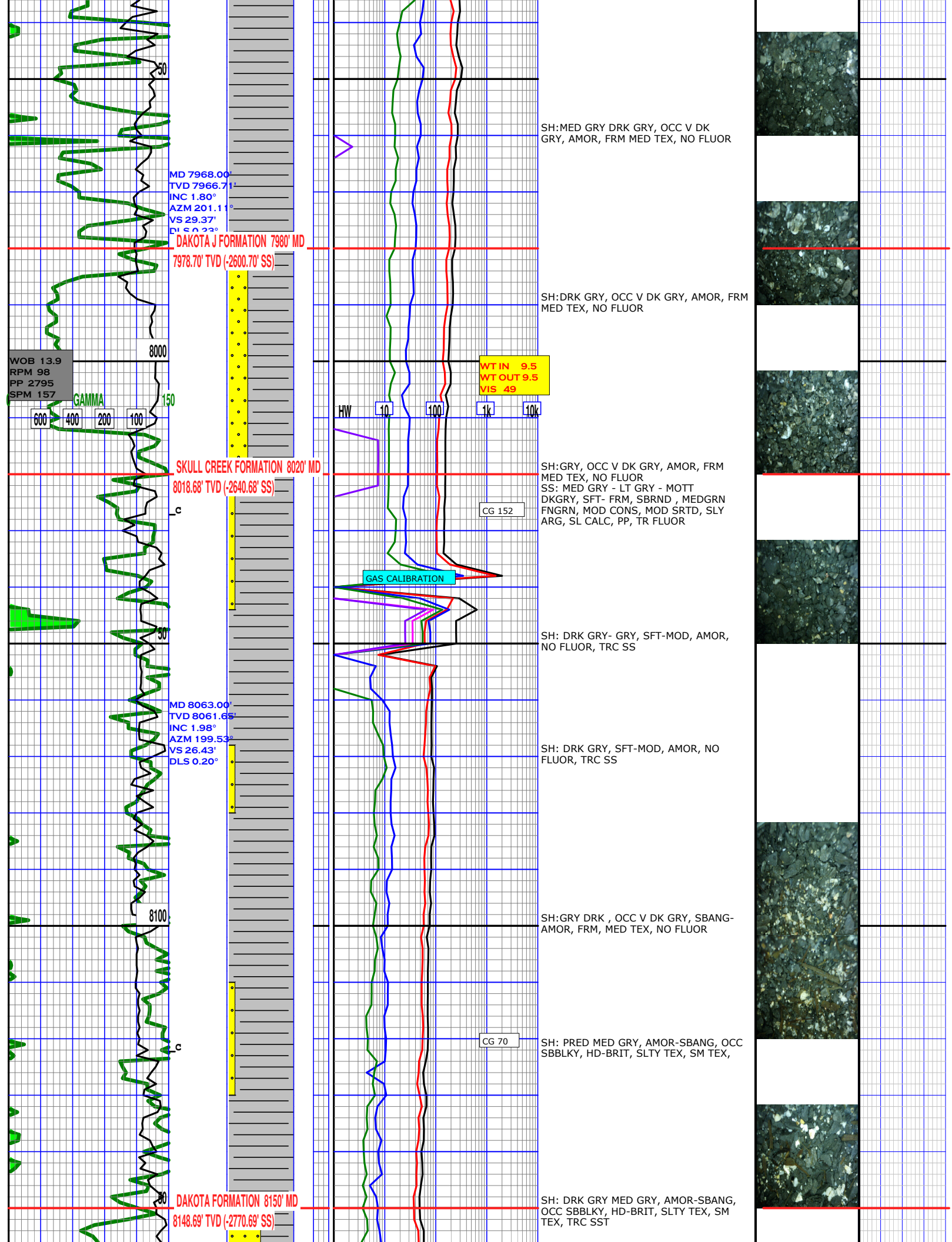

50
NIOBRARA FORMATION 6886' MD
6885.00' TVD (-1507.00' SS)
S
R
6900
MD 6927.00'
TVD 6925.99'
INC 1.63°
AZM 181.95°
VS 52.25'
DLS 0.06°
50
7000
WOB 6.3
RPM 77
PP 2809
SPM 156
GAMMA
150
600
400
200
100
MD 7022.00'
TVD 7020.94'
INC 1.41°
AZM 188.10°
VS 49.74'
DLS 0.29°
T.H
50
CG 115
CG 200
WT IN 9.5
WT OUT 9.45
VIS 50
HW
10
100
1k
10k
SH:GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD, OCC HD, SLTY TEX, TR SLTST, NO FLUOR
SH:GRY-MED GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD, OCC HD, SLTY TEX, TR SLTST, NO FLUOR
SH:MED GRY, OCC V DK GRY, SBANG, OCC AMOR, SLILY HD, OCC HD, SLTY TEX, TR SLTST, NO FLUOR
SH:MED GRY, OCC V DK GRY, SBANG, OCC AMOR, HD, OCC HD, TEX,NO FLUOR
SH:MED GRY- GRY, OCC V DK GRY, SBANG, OCC AMOR, HD, OCC HD, TEX,NO FLUOR
SH:GRY, OCC V DK GRY, SBANG, OCC AMOR, HD, OCC HD, TEX,NO FLUOR

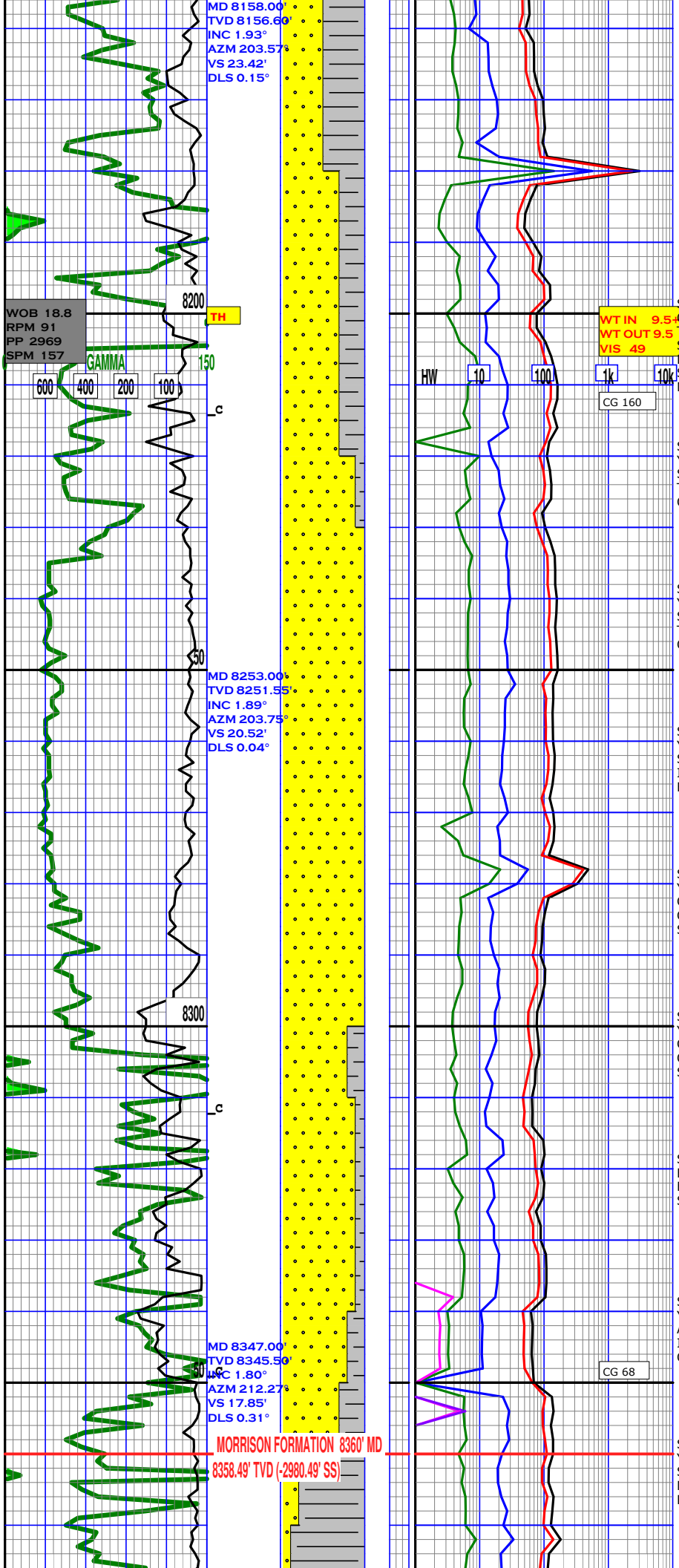

SH: MED-DK GRY, OCC V DK GRY, SBANG-AMOR, SLILY HD-BRIT, SM-EA TEX, NO FLUOR
CG 80
SH: PRED MED-DK GRY, SBANG-AMOR, OCC PLTY, FRM-SLILY HD, SM-EA TEX, NO FLUOR
7100
MD 7117.00'
TVD 7115.92'
INC 1.32°
AZM 179.84°
VS 47.49'
DLS 0.23°
SH: PRED MED-DK GRY, OCC V DK GRY, SBANG-AMOR, SLILY HD-BRIT, SM-EA TEX, TR LS, DULL YEL FLUOR
50
FORT HAYS 7152' MD
7150.91' TVD (-1772.91' SS)
SH: DK GRY, OCC V DK GRY, SBLKY-BLKY, OCC AMOR, SLILY HD-BRIT, SM-EA TEX, NO FLUOR
2/4/23
CG 208
SH: MED-DK GRY, OCC V DK GRY, SBANG-AMOR, FRM-SLILY HD, SM-EA TEX, NO FLUOR
7200
WOB 12.7
RPM 90
PP 2860
SPM 155
WT IN 9.5
WT OUT 9.45
VIS 50
GAMMA
150
600
400
200
100
HW
10
100
1k
10k
MD 7211.00'
TVD 7209.89'
INC 1.10°
AZM 175.80°
VS 45.51'
DLS 0.25°
SH: PRED MED-DK GRY, OCC LT GRY, SBANG-AMOR, SLILY HD-BRIT, SM-EA TEX, TR PYR, NO FLUOR
50
SH: PRED MED-DK GRY, SBANG-AMOR, OCC PLTY, MOD FRM-SLILY HD, SM-EA TEX, NO FLUOR
CG 92


7300
MD 7305.00'
TVD 7303.81'
INC 1.32°
AZM 181.86°
VS 43.53'
DLS 0.27°
CODELL FORMATION 7320' MD
7318.87' TVD (-1940.87' SS)
50
LC
GREENHORN FORMATION 7370' MD
7368.86' TVD (-1990.86' SS)
7400
MD 7400.00'
TVD 7398.85'
INC 1.01°
AZM 179.93°
VS 41.59'
DLS 0.33°
WOB 13.8
RPM 79
PP 3019
SPM 157
GAMMA
150
600
400
200
100
50
H.A
MD 7495.00'
TVD 7493.84'
HW
10
100
1k
10k
CG 46
WT IN 9.5
WT OUT 9.45
VIS 49
CG 30
LS: PRED WH-OFF WH, OCC CRM, OCC GRY, FLK, OCC BLKY, FRM TEX, CRYPXLN-MICXLN, SUC-CHK, MOD POR, DULL YEL FLUOR, NO CUT
LS: WH-OFF WH, OCC CRM, OCC GRY, BLKY-FLK, FRM TEX, CRYPXLN-MICXLN, SUC-CHK, MOD POR, NO FLUOR, NO CUT
SST: MED GRY-DK GRY, OCC LT GY, OCC YEL, FROS GR, F-CRS GR, SB RND, PRED MOD CONSOL, CALC, M INTGRN POR, MOD SRT, TR SLTST, NO FLUOR
SH: MED-DK GRY, OCC V DK GRY, SBANG-AMOR, SLILY HD-BRIT, SM-EA TEX, TR PYR, NO FLUOR
SH: MED-DK GRY, OCC V DK GRY, SBANG-SBLKY, FRM- SLILYHD, EA-GT, OCC PLTY TEX, NO FLUOR
SH: PRED MED-DK GRY, OCC V DK GRY, SBANG-AMOR, SLILY HD-BRIT, SM-EA TEX, NO FLUOR


7500
50
C
MD 7589.00'
TVD 7587.83'
INC 0.92°
AZM 181.95°
VS 38.49'
DLS 0.08°
7600
WOB 11.8
RPM 80
PP 3625
SPM 157
GAMMA
150
600
400
200
100
50
C
MD 7684.00'
TVD 7682.81'
GRANEROS FORMATION 7690' MD
7688.81' TVD (-2310.81' SS)
7700
CG 215
WT IN 9.5+
WT OUT 9.5
VIS 49
HW
10
100
1k
10k
CG 547
SH: PRED MED-DK GRY, OCC V DK GRY, SBANG-AMOR, SLILY HD-BRIT, SM-EA TEX, NO FLUOR
SH: PRED MED-DK GRY, OCC V DK GRY, SBANG-AMOR, HD-BRIT, SM-EA TEX, NO FLUOR
SH:DK GRY, OCC V DK GRY, SBANG-AMOR, SLILY HD-BRIT, SM-EA TEX, NO FLUOR
SH:DK GRY- GRY, OCC V DK GRY, SBANG-AMOR, SLILY HD-BRIT, SM-EA TEX, NO FLUOR
SH:DRK GRY, OCC V DK GRY, SBANG-AMOR, HD-BRIT, SM-EA TEX, NO FLUOR
SH:DRK GRY, OCC V DK GRY, SBANG-AMOR, HD-BRIT, SM-EA TEX, NO FLUOR
SH:DRK GRY-GRY, OCC V DK GRY, SBANG-AMOR, HD-BRIT, SM-EA TEX, NO FLUOR


SH:DRK GRY , OCC V DK GRY, SBANG-AMOR, HD, EA TEX, NO FLUOR
CG 614
SH:DRK GRY , OCC V DK GRY, SBANG-AMOR, HD-FRM, EA TEX, NO FLUOR
MD 7779.00'
TVD 7777.79'
INC 1.71°
AZM 186.08°
VS 34.59'
DLS 0.70°
SH:DRK GRY , OCC V DK GRY, SBANG-AMOR, HD-FRM, MED TEX, NO FLUOR
7800'
WOB 11.6
RPM 90
PP 2961
SPM 157
GAMMA
150
600
400
200
100
WT IN 9.5+
WT OUT 9.5
VIS 49
HW
10
100
1k
10k
SH:GRY, OCC V DK GRY, AMOR, FRM MED TEX, NO FLUOR
CG 471
50
HUNTSMAN FORMATION 7850' MD
7848.76' TVD (-2470.76' SS)
SH:GRY DRK GRY , OCC V DK GRY, SBANG-AMOR, FRM, MED TEX, NO FLUOR
SH:GRY DRK , OCC V DK GRY, SBANG-AMOR, FRM, MED TEX, NO FLUOR
MD 7874.00'
TVD 7872.75'
INC 1.58°
AZM 200.67°
VS 31.96'
DLS 0.46°
7900'
SH:GRY, OCC V DK GRY, SBANG-AMOR, FRM MED TEX, NO FLUOR
CG 367
SH:MED GRY, OCC V DK GRY, SBANG-AMOR, FRM MED TEX, NO FLUOR


MD 7968.00'
TVD 7966.71'
INC 1.80°
AZM 201.11°
VS 29.37'
DLS 0.23°
DAKOTA J FORMATION 7980' MD
7978.70' TVD (-2600.70' SS)
WOB 13.9
RPM 98
PP 2795
SPM 157
GAMMA
600
400
200
100
150
8000
WT IN 9.5
WT OUT 9.5
VIS 49
HW
10
100
1k
10k
SKULL CREEK FORMATION 8020' MD
8018.68' TVD (-2640.68' SS)
CG 152
GAS CALIBRATION
50
MD 8063.00'
TVD 8061.65'
INC 1.98°
AZM 199.53°
VS 26.43'
DLS 0.20°
8100
CG 70
DAKOTA FORMATION 8150' MD
8148.69' TVD (-2770.69' SS)
SH:MED GRY DRK GRY, OCC V DK GRY, AMOR, FRM MED TEX, NO FLUOR
SH:DRK GRY, OCC V DK GRY, AMOR, FRM MED TEX, NO FLUOR
SH:GRY, OCC V DK GRY, AMOR, FRM MED TEX, NO FLUOR
SS: MED GRY - LT GRY - MOTT DKGRY, SFT- FRM, SBRND , MEDGRN FNGRN, MOD CONS, MOD SRTD, SLY ARG, SL CALC, PP, TR FLUOR
SH: DRK GRY- GRY, SFT-MOD, AMOR, NO FLUOR, TRC SS
SH: DRK GRY, SFT-MOD, AMOR, NO FLUOR, TRC SS
SH:GRY DRK , OCC V DK GRY, SBANG-AMOR, FRM, MED TEX, NO FLUOR
SH: PRED MED GRY, AMOR-SBANG, OCC SBBLKY, HD-BRIT, SLTY TEX, SM TEX,
SH: DRK GRY MED GRY, AMOR-SBANG, OCC SBBLKY, HD-BRIT, SLTY TEX, SM TEX, TRC SST




SH: GRY MED GRY, AMOR-SBANG, OCC SBBLKY, HD-BRIT, SLTY TEX, SM TEX.
SST:PRED MED GRY-LT GRY - MOTT LT BRN, MOD FRM- FRM, SBRND TO SBRND,MEDGRN TO FNGRN, MODCONS MOD SRTD, SLY ARG, SL CALC, PP,

SD: OFF WH-CRM, OCC DK GY, OCC YELSH TAN, FROS GR, VCRS GR, SBANG-SBRND, GLOS, PRED UNCONSOL, TR CALC INCL, GD POR, MOD SRT, TR CHK, NO FLUOR

SD: PRED CRM, OCC RDSH TAN, OCC YELSH TAN, FROS GR, VCRS GR, SBANG-SBRND, PRED UNCONSOL, TR CALC INCL, GD POR, MOD SRT, TR CHK, NO FLUOR

SD: PRED WH-OFF WH, OCC BLK, OCC YELSH TAN, FROS GR, CRS GR, SBANG-SBRND, PRED UNCONSOL, TR CALC INCL, GD POR, POORLY SRT, TR CHK, NO FLUOR

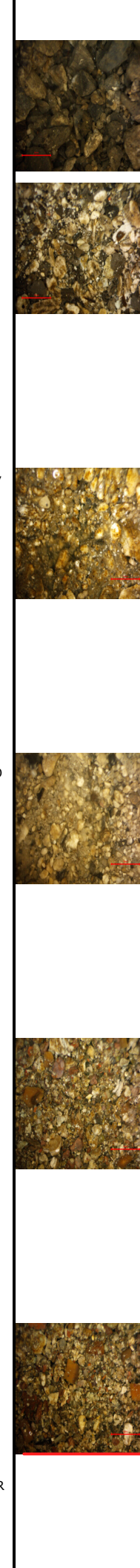
SD: PRED WH-CRM, OCC GRY, OCC YELSH TAN, V CRS GR, FROS GR, OCC GLOS GR, SBRND, PRED UNCONSOL, TR CALC INCL, MOD INTGRAN POR, MOD SRT, TR CHK, NO FLUOR

SD: PRED WH-OFF WH, OCC BLK, OCC YELSH TAN, CRS GR, OP GR, OCC GLOS GR, SBRND, PRED UNCONSOL, TR CALC INCL, MOD INTGRAN POR, MOD SRT, TR CHK, FNT OR FLUOR

SD: YELSH TAN-OFF WH, OCC RD, OCC BLK, FROS GR, MED GR, SBANG, PRED FRI-MOD CONSOL, TR CALC INCL, MOD SRT, TR MIC, TR FSPR, DULL OR FLUOR

SD: PRED WH-OFF WH, OCC CRM, OCC YELSH TAN, CRS GR, GLOS GR, OP GR, ANG-SBANG, PRED CONSOL, TR CALC INCL, MOD INTGRAN POR, MOD SRT, TR CHK, NO FLUOR

SD: PRED CRM-TAN, OCC BRN, OCC YELSH TAN, MED GR, FROS GR, ANG-SBANG, UNCONSOL, TR CALC INCL, MOD INTGRAN POR, MOD SRT, TR SH, TR FSPR, NO FLUOR



WOB 11.1
RPM 95
PP 2686
SPM 157

GAMMA
600 400 200 100

8400

MD 8418.20'
TVD 8416.66
INC 2.02°
AZM 211.04°
VS 15.83'
DLS 0.31°

2/5/23

Coring #1 2/7/2023

2/7/23 H.A

8500 T.H

SUNDANCE FORMATION 8520 MD ( -3142.00 SS )

2/9/23 H.A

TEST GAS

WT IN 9.5
WT OUT 9.5
VIS 47

HW 10 100 1k 10k

CG 46

CG 28

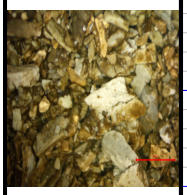
SHORT TRIP IN

SH: LT-MED GRY, OCC DK GRY, FLK-AMOR, OCC PLTY, SFT-FRM, SM-GT TEX, TR SST, NO FLUOR



SH: V LT-LT GRY, OCC MED GRY, SBANG-AMOR, OCC PLTY, SFT-FRM, SM-GT TEX, TR SST, NO FLUOR

SH: PRED V LT-LT GRY, OCC MED GRY, SBANG-AMOR, OCC FLK, FRM-SLILY HD, SM-GT TEX, TR SST, NO FLUOR



SH: OFF WH-LT GRY, OCC MED GRY, AMOR, OCC FLK, OCC PLTY, SLILY HD-BRIT, SM-GT TEX, TR SST, NO FLUOR



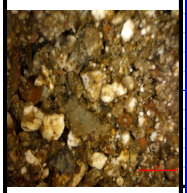
SH: PRED TAN SH-LT GRY, OCC OFF WH-MED GRY, AMOR, OCC FLK, OCC PLTY, BRIT-HD, GT TEX, TR SST, NO FLUOR

POOR SAMPLE QUALITY LCM CONTAMINATION, ABUNDENT CALCITE.



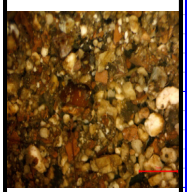
SH: PRED RED, TAN OCC-MED TAN, AMOR-PLTY, SBBLKY, FRM-BRIT, OCC SLILY HD, SLTY, TR SD, NO FLUOR

SH: PRED LT GRY-MED GRY, OCC RED, AMOR-PLTY, OCC SBANG, SFT-FRM, OCC SLILY HD, SLTY, TR SD, NO FLUOR

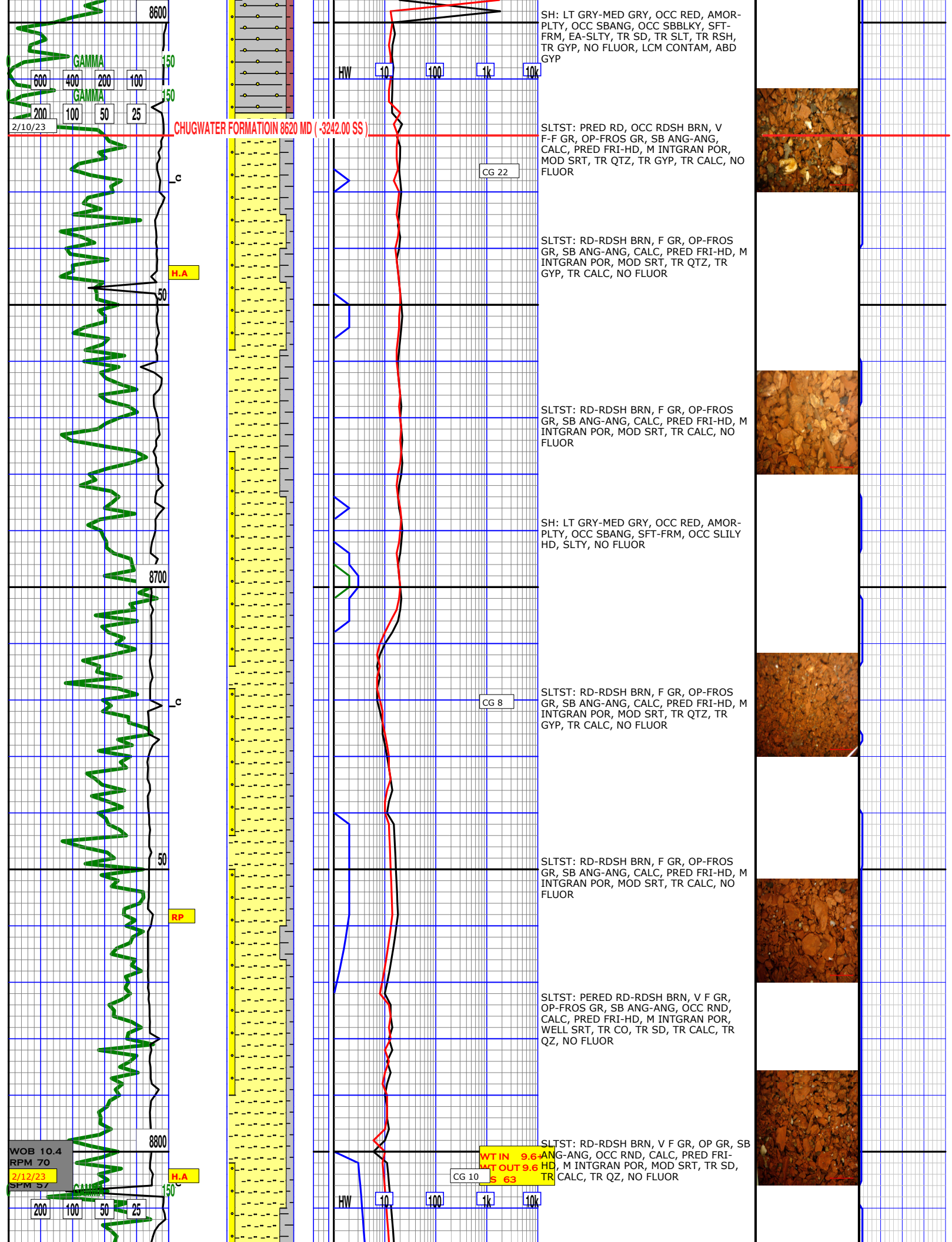


SH: LT GRY-MED GRY, OCC RED, AMOR-PLTY, OCC SBANG, SFT-FRM, OCC SLILY HD, SLTY, NO FLUOR

SH: TAN LT GRY, OCC MED GRY, AMOR-PLTY, OCC SBANG, SFT-FRM, OCC SLILY HD, SLTY, TR SD, TR SLT, TR RSH, TR GYP, NO FLUOR, LCM CONTAM, ABD GYP

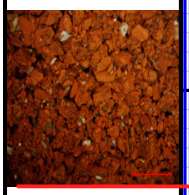


SH: PRED TAN LT GRY, OCC MED GRY, AMOR-SBANG, SFT-FRM, SLTY, TR SD, TR RSH, TR GYP, NO FLUOR, LCM CONTAM, ABD GYP


8600
GAMMA
600
400
200
100
150
GAMMA
200
100
50
25
150
2/10/23
CHUGWATER FORMATIOIN 8620 MD ( -3242.00 SS )
H.A
50
8700
50
RP
8800
WOB 10.4
RPM 70
2/12/23
SPM 57
H.A
GAMMA
150
200
100
50
25
HW
10
100
1k
10k
CG 22
CG 8
CG 10
WT IN 9.6+
WT OUT 9.6
S 63
SH: LT GRY-MED GRY, OCC RED, AMOR-PLTY, OCC SBANG, OCC SBBLKY, SFT-FRM, EA-SLTY, TR SD, TR SLT, TR RSH, TR GYP, NO FLUOR, LCM CONTAM, ABD GYP
SLTST: PRED RD, OCC RDSH BRN, V F-F GR, OP-FROS GR, SB ANG-ANG, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR QTZ, TR GYP, TR CALC, NO FLUOR
SLTST: RD-RDSH BRN, F GR, OP-FROS GR, SB ANG-ANG, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR QTZ, TR GYP, TR CALC, NO FLUOR
SLTST: RD-RDSH BRN, F GR, OP-FROS GR, SB ANG-ANG, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR CALC, NO FLUOR
SH: LT GRY-MED GRY, OCC RED, AMOR-PLTY, OCC SBANG, SFT-FRM, OCC SLILY HD, SLTY, NO FLUOR
SLTST: RD-RDSH BRN, F GR, OP-FROS GR, SB ANG-ANG, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR QTZ, TR GYP, TR CALC, NO FLUOR
SLTST: RD-RDSH BRN, F GR, OP-FROS GR, SB ANG-ANG, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR CALC, NO FLUOR
SLTST: PERED RD-RDSH BRN, V F GR, OP-FROS GR, SB ANG-ANG, OCC RND, CALC, PRED FRI-HD, M INTGRAN POR, WELL SRT, TR CO, TR SD, TR CALC, TR QZ, NO FLUOR
SLTST: RD-RDSH BRN, V F GR, OP GR, SB ANG-ANG, OCC RND, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR SD, TR CALC, TR QZ, NO FLUOR

SLTST: PRED RD-RDSH BRN, V F GR, OP GR, SB ANG-ANG, CALC, PRED FRI- SLILY HD, M INTGRAN POR, WELL SRT, TR SD, TR CALC, NO FLUOR

SLTST: RD-RDSH BRN, V F-F GR, OP GR, OCC FROS, SB ANG-ANG, CALC, PRED FRI- SLILY HD, M INTGRAN POR, MOD SRT, TR SD, TR CALC, F.Q.G, NO FLUOR

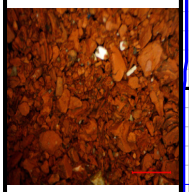


50

LYKINS FORMATION 8860 MD ( -3482.00 SS )

SLTST: RD-RDSH BRN, V F-F GR, OP GR, OCC FROS, SB ANG-ANG, CALC, PRED FRI- SLILY HD, M INTGRAN POR, MOD SRT, TR SD, TR CALC, F.Q.G, NO FLUOR

SLTST: RD-RDSH BRN, V F GR, OP GR, SB ANG-ANG, CALC, PRED FRI- SLILY HD, M INTGRAN POR, WELL SRT, TR GYP, TR SD, NO FLUOR



8900

C

CG 20

SLTST: PRED RD-RDSH BRN, V F GR, OP GR, SB ANG-ANG, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR SD, TR CALC, NO FLUOR

2/13/23

SLTST: RD-RDSH BRN, V F-F GR, OP GR, SB ANG-ANG, CALC, PRED FRI- SLILY HD, GD POR, WELL SRT, TR SD, TR CALC, TR GYP, NO FLUOR

H.A

50

SLTST: RD-RDSH BRN, V F GR, OP GR, SB ANG-ANG, CALC, PRED FRI- SLILY HD, M INTGRAN POR, WELL SRT, TR GYP, TR ANHY, TR SD, NO FLUOR



C

R.P

2/14/23

2/15/23

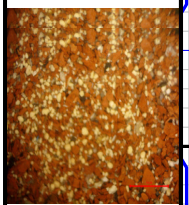
CG 33

ANHY: PK, SFT,GRAN, CONCH, EUHED, DL. HAL:WH, SFT, AMOR, CONCH, SUBHED,VIT. SH: RD-PK, SFT, EA, BLKY, DISSEM, ANHY

H.A

ANHY: WH-OFF WH, OCC PK, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, ABD HAL, TR CO, TR GYP, NO FLUOR

SLTST: RD-RDSH BRN, V F GR, OP GR, SB ANG-ANG, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR SD, TR CALC, NO FLUOR



9000

WOB 8.8
RPM 70
PP 960
SPM 64

WT IN 9.7
WT OUT 9.7
VIS 67

GAMMA

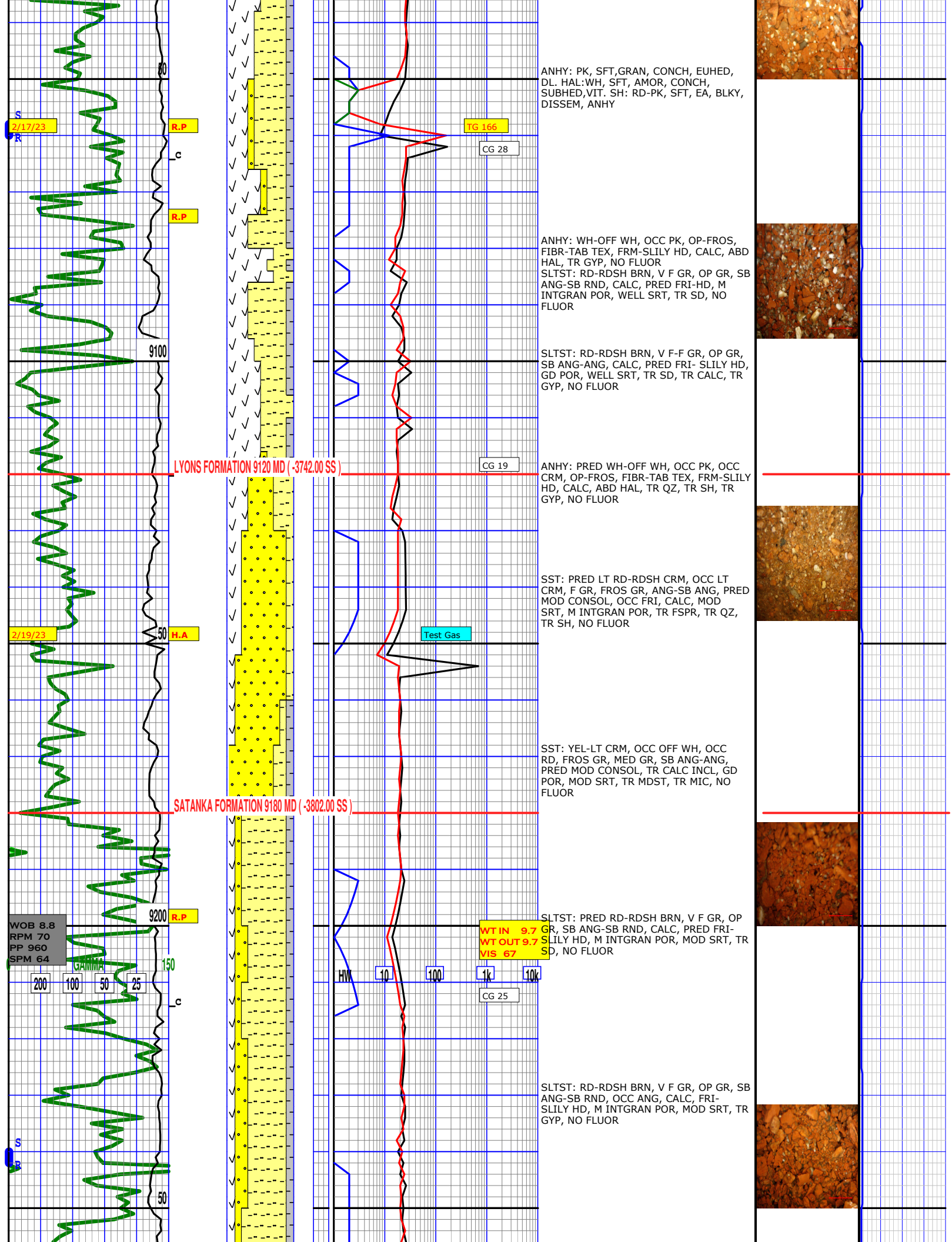
150

200 100 50 25

HW 10 100 1k 10k

SLTST: PRED RD-RDSH BRN, V F GR, OP GR, SB ANG-ANG, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR SD, TR CALC, NO FLUOR






ANHY: PK, SFT,GRAN, CONCH, EUHED, DL. HAL:WH, SFT, AMOR, CONCH, SUBHED,VIT. SH: RD-PK, SFT, EA, BLKY, DISSEM, ANHY

ANHY: WH-OFF WH, OCC PK, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, ABD HAL, TR GYP, NO FLUOR
SLTST: RD-RDSH BRN, V F GR, OP GR, SB ANG-SB RND, CALC, PRED FRI-HD, M INTGRAN POR, WELL SRT, TR SD, NO FLUOR

SLTST: RD-RDSH BRN, V F-F GR, OP GR, SB ANG-ANG, CALC, PRED FRI- SLILY HD, GD POR, WELL SRT, TR SD, TR CALC, TR GYP, NO FLUOR

ANHY: PRED WH-OFF WH, OCC PK, OCC CRM, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, ABD HAL, TR QZ, TR SH, TR GYP, NO FLUOR

SST: PRED LT RD-RDSH CRM, OCC LT CRM, F GR, FROS GR, ANG-SB ANG, PRED MOD CONSOL, OCC FRI, CALC, MOD SRT, M INTGRAN POR, TR FSPR, TR QZ, TR SH, NO FLUOR

SST: YEL-LT CRM, OCC OFF WH, OCC RD, FROS GR, MED GR, SB ANG-ANG, PRED MOD CONSOL, TR CALC INCL, GD POR, MOD SRT, TR MDST, TR MIC, NO FLUOR

SLTST: PRED RD-RDSH BRN, V F GR, OP GR, SB ANG-SB RND, CALC, PRED FRI-SLILY HD, M INTGRAN POR, MOD SRT, TR SD, NO FLUOR

SLTST: RD-RDSH BRN, V F GR, OP GR, SB ANG-SB RND, OCC ANG, CALC, FRI-SLILY HD, M INTGRAN POR, MOD SRT, TR GYP, NO FLUOR

2/21/23

H.A

C

9300

R.P

50

C

9400

WOB 12.8
RPM 100
PP 2582
SPM 79

GAMMA

200 100 50 25 150

2/22/23

50

Trip GAS 106

CG 17

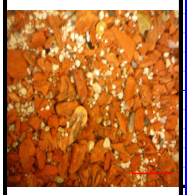
CG 25

WT IN 9.8
WT OUT 9.7
VIS 58

HW 10 100 1k 10k

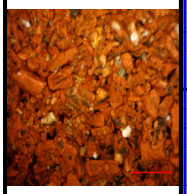
WOLFCAMPIAN FORMATION 9380 MD ( -4002.00 SS )

SLTST: PRED RD-RDSH BRN, V F-F GR, OP GR, SB ANG-ANG, OCC SB RND, CALC, PRED FRI- SLILY HD, GD POR, MOD SRT, TR CALC, TR GYP, NO FLUOR



SLTST: RD-RDSH BRN, V F GR, OP GR, SB ANG-SB RND, CALC, PRED FRI- SLILY HD, M INTGRAN POR, MOD SRT, TR SD, TR PURP SLTST, TR CO, TR DOL, NO FLUOR

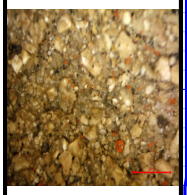
SLTST: PRED RD-RDSH BRN, V F GR, OCC F GR, OP-FROS GR, SB ANG-ANG, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR DOL, TR CO, NO FLUOR



SLTST: RD-RDSH BRN, V F-F GR, OP GR, SB ANG-ANG, OCC SB RND, CALC, FRI-SLILY HD, OCC FRM, M INTGRAN POR, MOD SRT, TR GYP, TR DOL, NO FLUOR

ANHY: WH-OFF WH, OCC CRM, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, TR GYP, NO FLUOR

SLTST: RD-RDSH BRN, V F GR, OP GR, SB ANG-SB RND, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR SD, TR CO, NO FLUOR



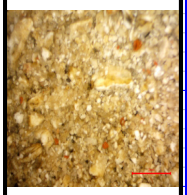
ANHY: WH-OFF WH, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, IMBEDDED DOLOSTONE, TR CO, TR GYP, NO FLUOR

ANHY: PRED WH-OFF WH, OCC LT GRY, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, IMBEDDED DOLOSTONE, TR CO, TR GYP, TR BL SH, NO FLUOR



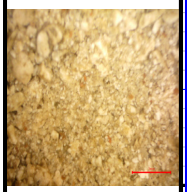
GAMMA API
0
150
H.A
9500
50
9600
WOB 25.2
RPM 76
PP 2585
SPM 158
GAMMA
0
150
200
100
50
25
R.P
50
Test Gas Trap and Lines
CG 30
WT IN 9.8
WT OUT 9.8
VIS 63
HW
10
100
Calculate Gas
10k
CG 26

ANHY: WH-OFF WH, OCC PK, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, IMBEDDED DOL, TR CO, TR SD, NO FLUOR

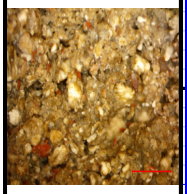


ANHY: WH-OFF WH, OCC CRM, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, TR GYP, NO FLUOR
SLTST: RD-RDSH BRN, V F GR, OP GR, SB ANG-SB RND, CALC, PRED FRI-HD, M INTGRAN POR, MOD SRT, TR SD, TR CO, NO FLUOR

ANHY: PRED WH-OFF WH, OCC LT GRY, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, IMBEDDED DOLOSTONE, TR CO, TR GYP, TR BL SH, NO FLUOR



ANHY: WH-OFF WH, OCC PK, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, IMBEDDED DOL, TR CO, TR SD, NO FLUOR



ANHY: PRED WH-OFF WH, OCC PK, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, ABD DOL, TR PURP SLTST, TR SD, NO FLUOR

ANHY: WH-OFF WH, OCC LT GRY, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, IMBEDDED DOL, NO FLUOR

9700

50

9800

WOB 21.0
RPM 76
PP 2554
SPM 157

GAMMA
0
200
100
50
25
150

2/23/23

TD REACHED @9850'MD ON 2/23/23

50

H.A

GAMMA API
0
150

CG 45

WT IN 9.8
WT OUT 9.8
VIS 53

HW
10
100
1k
10k

CG 50

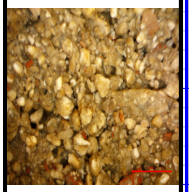
ANHY: PRED WH-OFF WH, OCC PK, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, ABD DOL, TR PURP SLTST, NO FLUOR

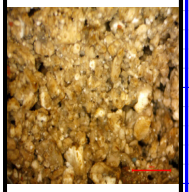
ANHY: WH-OFF WH, OCC LT CRM, OP-FROS, FIBR-TAB TEX, SFT-FRM, CALC, IMBEDDED DOL, TR SH, TR CO, NO FLUOR

ANHY: PRED WH-OFF WH, OCC LT GRY, OP-FROS, FIBR-TAB TEX, FRM-SLILY HD, CALC, IMBEDDED DOLOSTONE, TR GYP, TR BL SH, NO FLUOR

ANHY: WH-OFF WH, OCC LT GRY, OCC PK, OP-FROS, FIBR-TAB TEX, SFT-FRM, OCC SLILY HD, CALC, ABD DOL, TR GYP, TR RD-PURP INTBD SLTST, NO FLUOR

ANHY: PRED WH-PK, OCC OFF WH, OCC CRM, OP-FROS, FIBR-TAB TEX, SFT-FRM, CALC, IMBEDDED DOL, TR RD SLTST, NO FLUOR







**Response to Specific Comments, SC-13**

**Mass Spec Log_Juniper M-1**



# Mass Spec Log

Mass Spec Log Cover Sheet
www.ms.gov.com

Mass Spec Log Cover Sheet

Well Name: Thomas Bell 1H (Rev. A)
Location: Section 26, T23N, R6W
Lease Name: Thomas Bell Well #: 1H
Operator: XYZ Energy Operator #: 123456
Spud Date: 3/1/2015
Total Depth: 15,000 ft
Total Depth Date: 3/15/2015
Total Logged Depth: 15,000 ft
Logged Depth Date: 3/15/2015

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Mass Spec Log, LLC | 1 MSL Plaza | www.ms.gov.com



**Response to Specific Comments, SC-13**

**Juniper M-1 TCOM**

Company: TALLGRASS HIGH PLAINS CARBON STORAGE, LLC

Well: Juniper M-1

Field: Wildcat

County: Laramie State: Wyoming

TCOM

| | | | | | |
|---|---|---|---|---|---|
| Location: | 300' FNL & 660' FWL<br>Sec. 36, T13N, R62W | | Elev.: | K.B. | 5377.00 ft |
| | | | | G.L. | 5351.00 ft |
| | | | | D.F. | 5376.00 ft |
| | Permanent Datum: | Ground Level | Elev.: | | 5351.00 f |
| | Log Measured From: | Kelly Bushing | 26.00 ft | | above Perm.Datum |
| | Drilling Measured From: | Kelly Bushing | | | |

| API Serial No. | Section: | Township: | Range: |
|---|---|---|---|
| 49-021-29548-00 | 36 | 13N | 62W |

County: Laramie
Field: Wildcat
Location: 300' FNL & 660' FWL
Well: Juniper M-1
Company: TALLGRASS HIGH PLAINS CARBON STORAGE, LLC

| | | | | | | |
|---|---|---|---|---|---|---|
| Logging Date | | | 23-Feb-2023 | | | |
| Run Number | | | 1A | | | |
| Depth Driller | | | 9850.00 ft | | | |
| Schlumberger Depth | | | 9864.00 ft | | | |
| Bottom Log Interval | | | 9856.00 ft | | | |
| Top Log Interval | | | 1554.00 ft | | | |
| Casing Driller Size @ Depth | | | 9.625 in @ 1553.00 ft | | | |
| Casing Schlumberger | | | 1554 ft | | | |
| Bit Size | | | 8.75 in | | | |
| Type Fluid In Hole | | | OBM | | | |
| MUD | Density | Viscosity | 9.8 lbm/gal | 28 s | | |
| | Fluid Loss | PH | 100 cm3 | 8 | | |
| | Source of Sample | | N/A | | | |
| RM @ Meas Temp | | | N/A | | | |
| RMF @ Meas Temp | | | N/A | | | |
| RMC @ Meas Temp | | | N/A | | | |
| Source RMF | RMC | | N/A | N/A | | |
| RM @ BHT | RMF @ BHT | | N/A | N/A | | |
| Max Recorded Temperatures | | | 237.66 degF | | | |
| Circulation Stopped | Time | | 22-Feb-2023 | 16:00:00 | | |
| Logger on Bottom | Time | | 23-Feb-2023 | 23:36:00 | | |
| Unit Number | Location: | | 9102 | Fort Morgan, CO | | |
| Recorded By | | | J. Knapp / Y. Suitella | | | |
| Witnessed By | | | Joe Comisky | | | |

## Disclaimer

THE USE OF AND RELIANCE UPON THIS RECORDED-DATA BY THE HEREIN NAMED COMPANY (AND ANY OF ITS AFFILIATES, PARTNERS, REPRESENTATIVES, AGENTS, CONSULTANTS AND EMPLOYEES) IS SUBJECT TO THE TERMS AND CONDITIONS AGREED UPON BETWEEN SCHLUMBERGER AND THE COMPANY, INCLUDING: (a) RESTRICTIONS ON USE OF THE RECORDED-DATA; (b) DISCLAIMERS AND WAIVERS OF WARRANTIES AND REPRESENTATIONS REGARDING COMPANY'S USE AND RELIANCE UPON THE RECORDED-DATA; AND (c) CUSTOMER'S FULL AND SOLE RESPONSIBILITY FOR ANY INFERENCE DRAWN OR DECISION MADE IN CONNECTION WITH THE USE OF THIS RECORDED-DATA.

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11. Calibration Report
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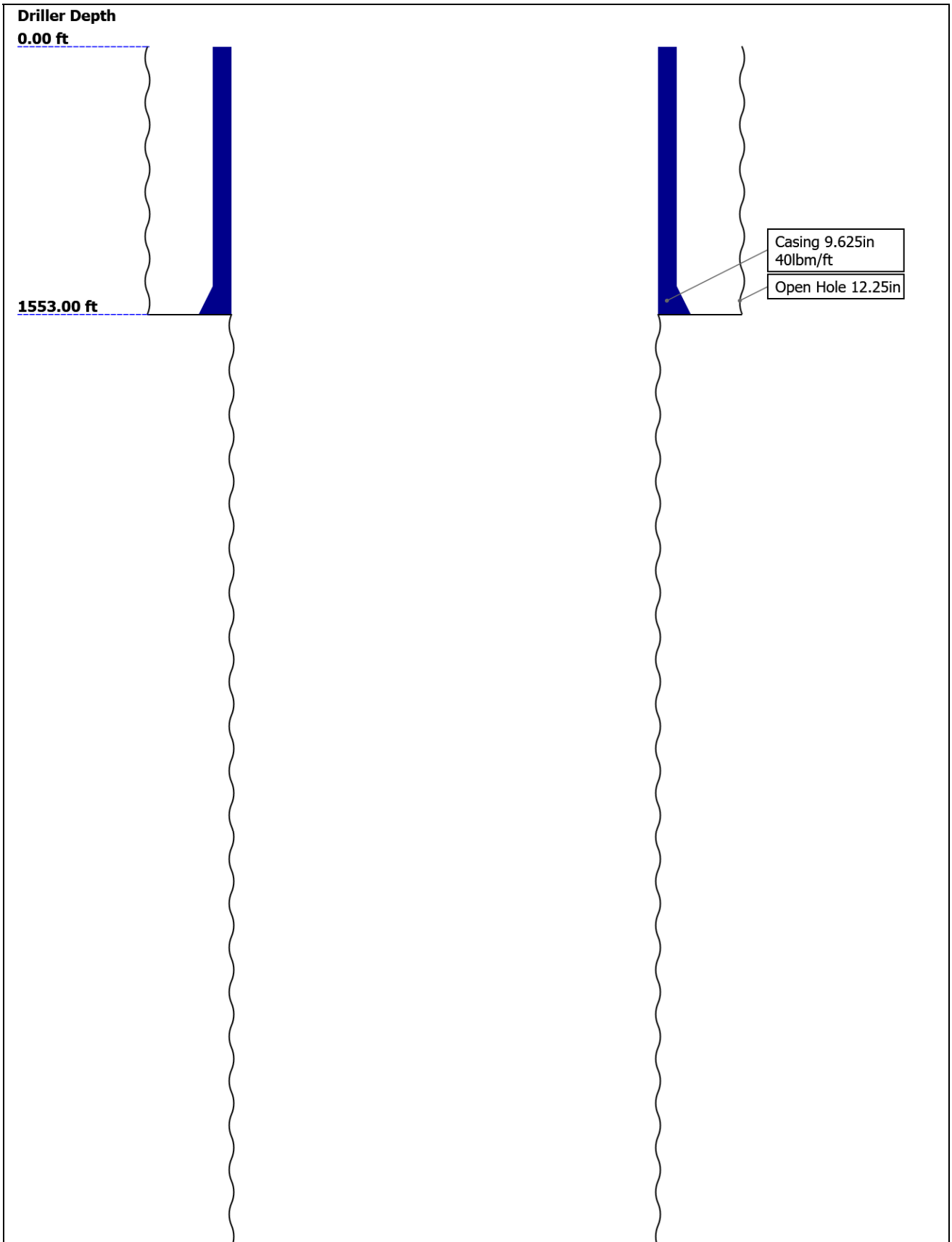
13.1 Integration Summary

## Well Sketch






## Borehole Size/Casing/Tubing Record

| | | | | | | |
|---|---|---|---|---|---|---|
| Bit | | | | | | |
| Bit Size ( in ) | 12.25 | 8.75 | | | | |
| Top Driller ( ft ) | 0 | 1553 | | | | |
| Top Logger ( ft ) | 0 | 1553 | | | | |
| Bottom Driller ( ft ) | 1553 | 9850 | | | | |
| Bottom Logger ( ft ) | 1553 | 9864 | | | | |
| Casing | | | | | | |
| Size ( in ) | 9.625 | | | | | |
| Weight ( lbm/ft ) | 40 | | | | | |
| Inner Diameter ( in ) | 8.835 | | | | | |
| Grade | J55 | | | | | |
| Top Driller ( ft ) | 0 | | | | | |
| Top Logger ( ft ) | 0 | | | | | |
| Bottom Driller ( ft ) | 1553 | | | | | |
| Bottom Logger ( ft ) | 1554 | | | | | |

## Remarks and Equipment Summary

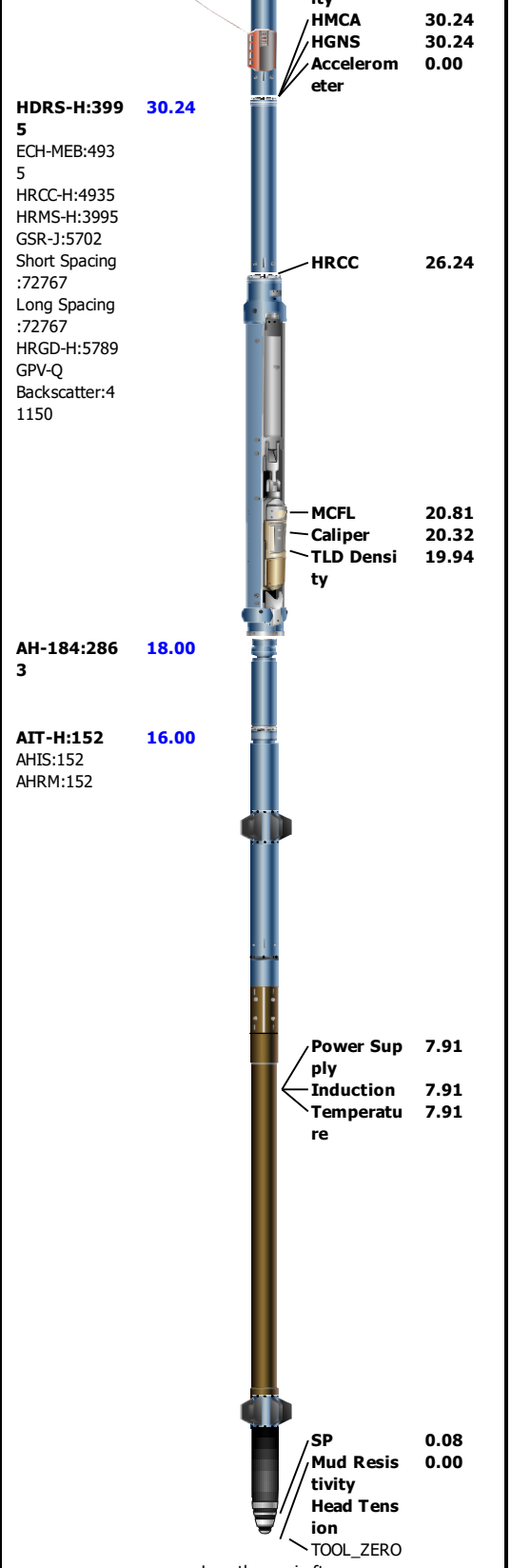
### 1A: Toolstring

| Equip name | Length | MP name | Offset |
|---|---|---|---|
| **LEH-QT** | **49.64** | | |
| LEH-QT | | | |
| **EDTC-B:9107** | **46.15** | | |
| EDTH-B:8014 | | | |
| EDTG-A:79285 | | | |
| EDTC-B:9107 | | | |
| | | **CTEM** | **42.65** |
| | | **ACCZ** | **0.00** |
| | | **HV** | **0.00** |
| | | **Gamma Ray** | **40.78** |
| | | **TelStatus** | **39.65** |
| **HGNS-H:3964** | **39.65** | **Temperature** | **39.62** |
| HGNH:3964 | | | |
| NPV-N:3964 | | | |
| NSR-F:5070 | | | |
| HGNS-H:3964 | | | |
| HMCA-H:4166 | | | |
| HACCZ-H:4166 | | | |
| | | **GR** | **38.91** |
| | | **CNL Porosity** | **32.58** |



### 1A: Remarks

- Limestone matrix used, MDEN = 2.71 g/cc
- Hole size and Standoff corrections applied to neutron porosity
- Max recorded temperature = 237.66 deg F from HGNS CTEM channel.
- Cement volume calculated using FCD = 5.5 inch
- Repeat pass recorded 400 ft above TD
- Main pass recorded from TD to CS, then CNL-GR to surface
- Caliper adjusted to nominal casing ID = 8.835 inch




Lengths are in ft
Maximum Outer Diameter = 7.000 in
Line: Sensor Location, Value: Gating Offset
All measurements are relative to TOOL_ZERO

## Depth Summary

| | 1A | | |
|---|---|---|---|
| **Depth Measuring Device** | | | |
| Type | IDW-JA | | |
| Serial Number | 6611 | | |
| Calibration Date | 07-Dec-2022 | | |
| Calibrator Serial Number | IDW-C 57 | | |

| | | | |
|---|---|---|---|
| Calibration Cable Type | 7-46 AXS | | |
| Wheel Correction 1 | -5 | | |
| Wheel Correction 2 | -6 | | |

## Tension Device

| | | | |
|---|---|---|---|
| Type | CMTD-B/A | | |
| Serial Number | 1223 | | |
| Calibration Date | 23-Feb-2023 | | |
| Calibrator Serial Number | 123 | | |
| Number of Calibration Points | 10 | | |
| Calibration Root Mean Square Error | 15 | | |
| Calibration Peak Error | 25 | | |

## Logging Cable

| | | | |
|---|---|---|---|
| Type | 7-46A-XS | | |
| Serial Number | F721083 | | |
| Length | 24000.00 ft | | |
| Conveyance Type | Wireline | | |
| Rig Type | Land | | |

| 1A:Depth Control Parameters | | Depth Control Remarks |
|---|---|---|
| Log Sequence | First Log In the Well | Schlumberger depth control procedures followed |
| Rig Up Length At Surface | 136.50 ft | IDW used as primary depth control system |
| Rig Up Length At Bottom | 136.30 ft | Z-Chart used as secondary depth control system |
| Rig Up Length Correction | 0.20 ft | Main and Repeat passes correlated to Down Log as reference. |
| Stretch Correction | 3.80 ft | |
| Tool Zero Check At Surface | 0.76 ft | |

# 1A

# Main Pass 2" = 100'

## Integration Summary

| Output Channel(s) | Output Description | Input Parameter | Output Value | Unit |
|---|---|---|---|---|
| IHV | Integrated Hole Volume | GCSE_UP_PASS | 3376.66 | ft3 |
| ICV | Integrated Cement Volume | GCSE_UP_PASS, FCD | 2004.53 | ft3 |

## Software Version

| Acquisition System | Version |
|---|---|
| Maxwell 2023.0 | 13.0.221437.3100 |

## Pass Summary

| Run Name | Pass Objective | Direction | Top | Bottom | Start | Stop | DSC Mode | Depth Shift | Include Parallel Data |
|---|---|---|---|---|---|---|---|---|---|
| 1A | Main[3]:Up | Up | 41.16 ft | 9870.33 ft | 23-Feb-2023 11:36:23 PM | 24-Feb-2023 2:35:46 AM | ON | 3.80 ft | Yes |

All depths are referenced to toolstring zero

## Log

Company:TALLGRASS HIGH PLAINS CARBON STORAGE, LLC Well:Juniper M-1

1A: Main[3]:Up:S009

Description: Triple Combo standard resolution template for Platform Express Format: Log ( TCOM 2in ) Index Scale: 2 in per 100 ft Index Unit: ft Index Type: Measured Depth Creation Date: 24-Feb-2023 02:44:15

| Channel | Source | Sampling |
|---|---|---|
| AT10 | AIT-H:AHIS:AHIS | 3in |
| AT20 | AIT-H:AHIS:AHIS | 3in |

| | | |
|---|---|---|
| AT30 | AIT-H:AHIS:AHIS | 3in |
| AT60 | AIT-H:AHIS:AHIS | 3in |
| AT90 | AIT-H:AHIS:AHIS | 3in |
| CALI | HDRS-H:HRCC-H:HRCC-H | 1in |
| DPHZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| DSOZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| GR_CAL | HGNS-H:HGNS-H:HGNS-H | 6in |
| HDRA | HDRS-H:HRMS-H:HRGD-H | 2in |
| ICV | Borehole | 6in - RT |
| IHV | Borehole | 6in - RT |
| PEFZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| PXND | PEQL | 6in |
| RSOZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| SP | AIT-H:AHIS:AHIS | 6in |
| TENS | WLWorkflow | 1in |
| TIME_1900 | WLWorkflow | 0.1in |
| TNPH | HGNS-H:HGNS-H:HGNS-H | 6in |

IHV - Integrated Hole Volume every 100.00 (ft3)

ICV - Integrated Cement Volume every 10.00 (ft3)

ICV - Integrated Cement Volume every 100.00 (ft3)

IHV - Integrated Hole Volume every 10.00 (ft3)

TIME_1900 - Time Marked every 60.00 (s)

Caliper (HCAL) HDRS-H
6 in 16

Spontaneous Potential (SP) AIT-H
-80 mV 20

Cable Tension (TENS)
10000 lbf 0

Calibrated Gamma Ray (GR) HGNS-H
0 gAPI 150

Standard Resolution Density Standoff (DSOZ) HDRS-H
2.5 in 0

Resistivity Standoff Standard Resolution (RSOZ) HDRS-H
2.5 in 0

DSOA

RSOA

Array Induction Two Foot Resistivity A10 (AHT10) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A20 (AHT20) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A30 (AHT30) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A60 (AHT60) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A90 (AHT90) AIT-H
0.2 ohm.m 2000

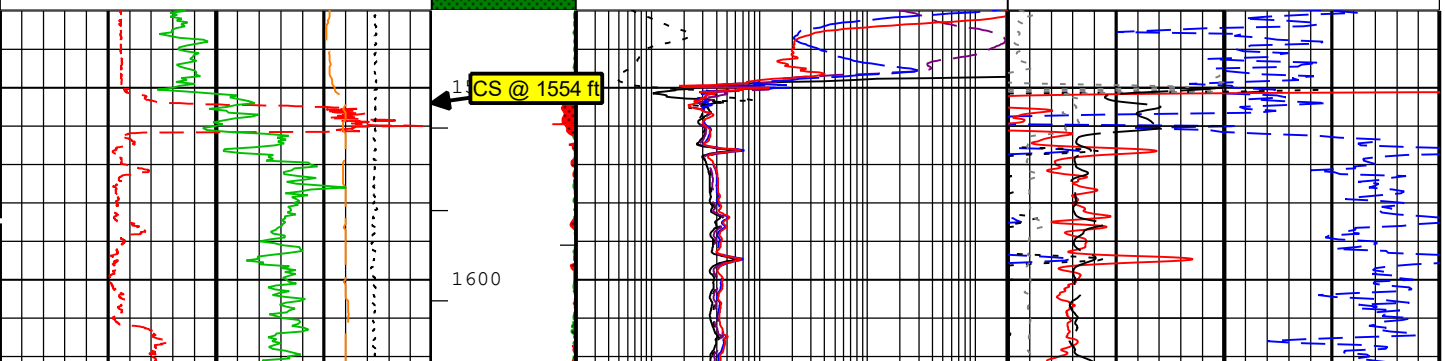
Density Standoff Correction (HDRA) HDRS-H
-0.05 g/cm3 0.45

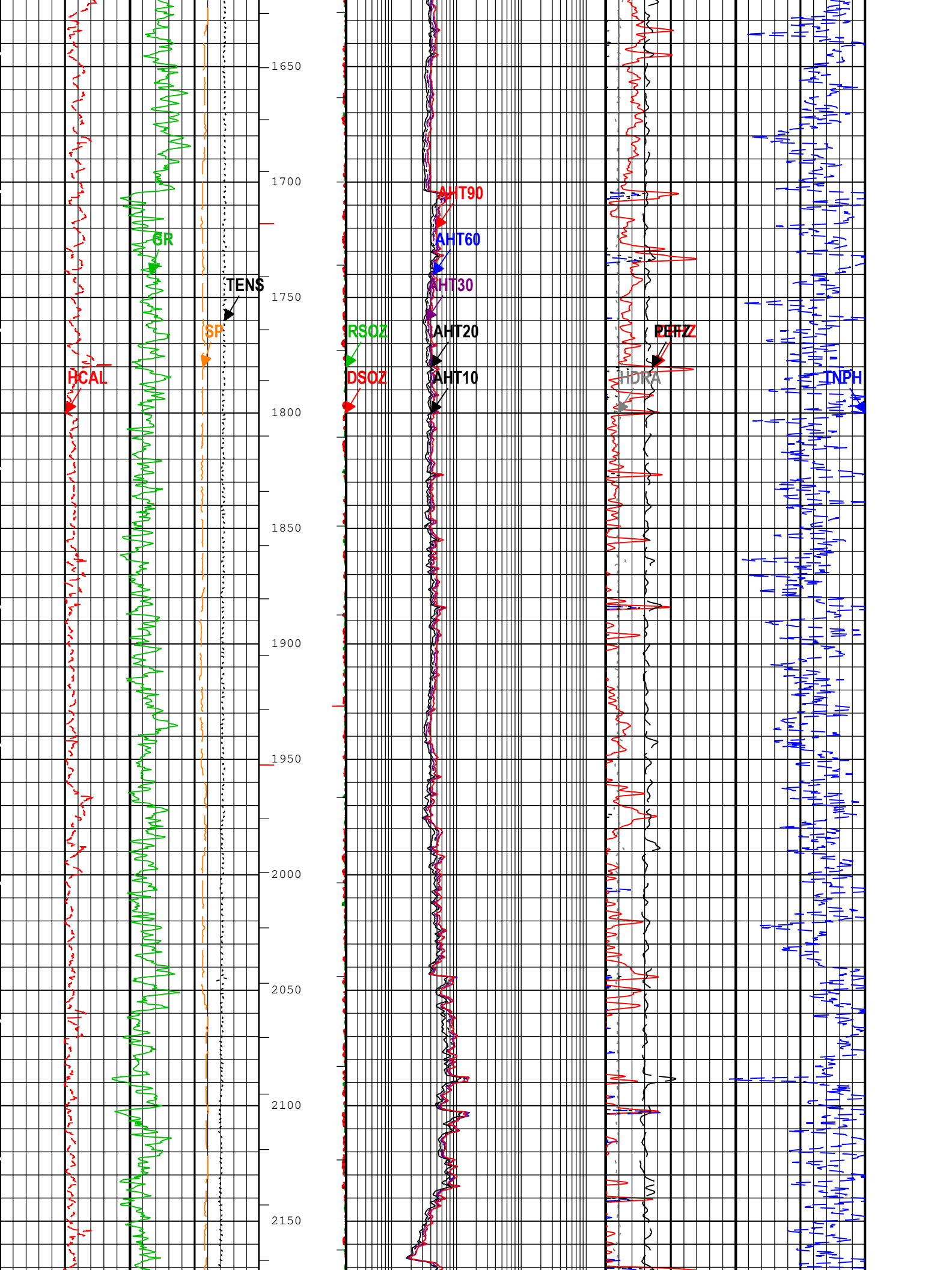
Standard Resolution Formation Photoelectric Factor (PEFZ) HDRS-H
0 10

Thermal Neutron Porosity (Ratio Method) in Selected Lithology (TNPH) HGNS-H
0.3 ft3/ft3 -0.1

Standard Resolution Density Porosity (DPHZ) HDRS-H
0.3 ft3/ft3 -0.1

Crossplot Porosity for Neutron-Density (PXND_HILT)
0.3 ft3/ft3 -0.1

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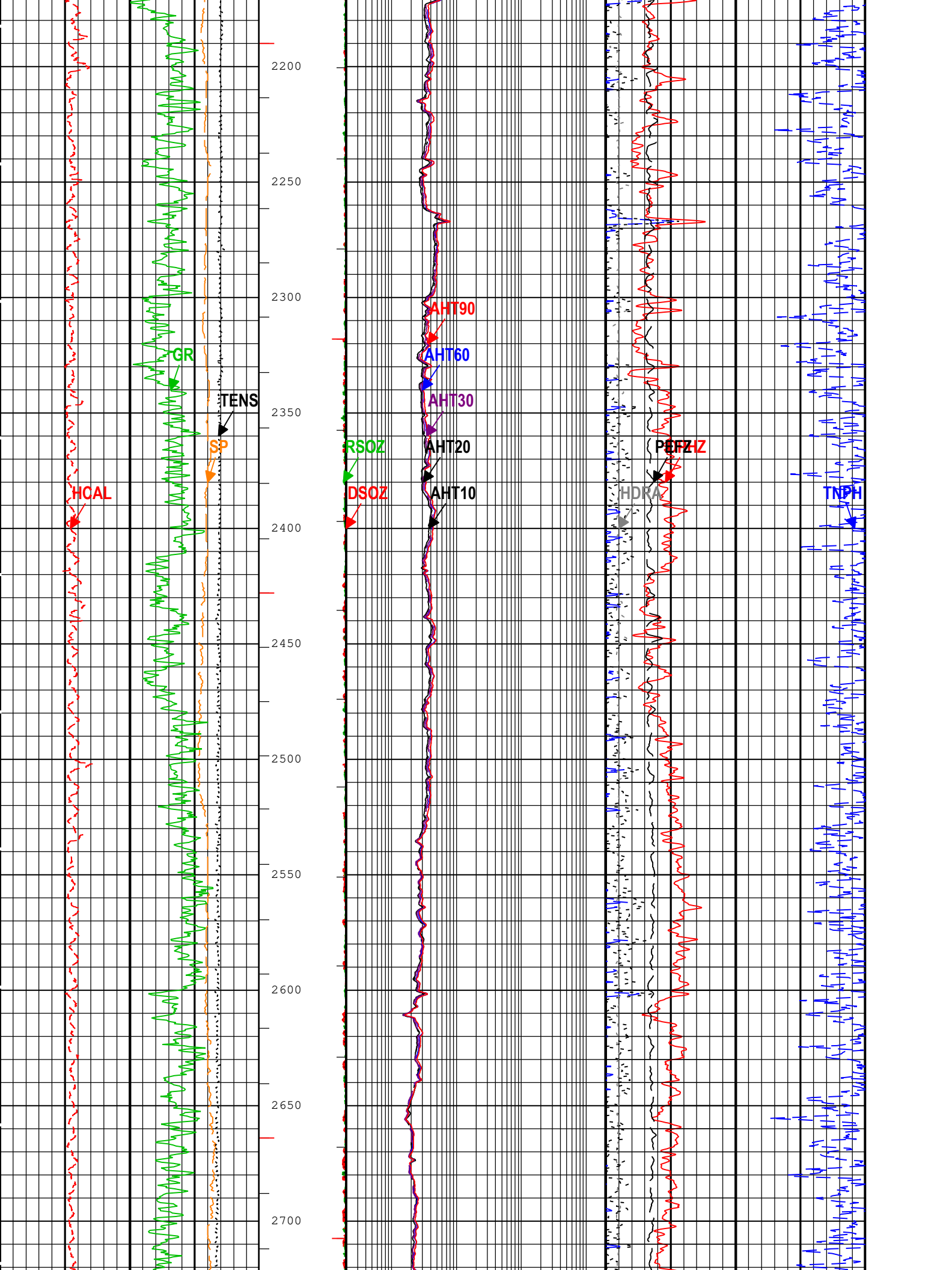
TNPH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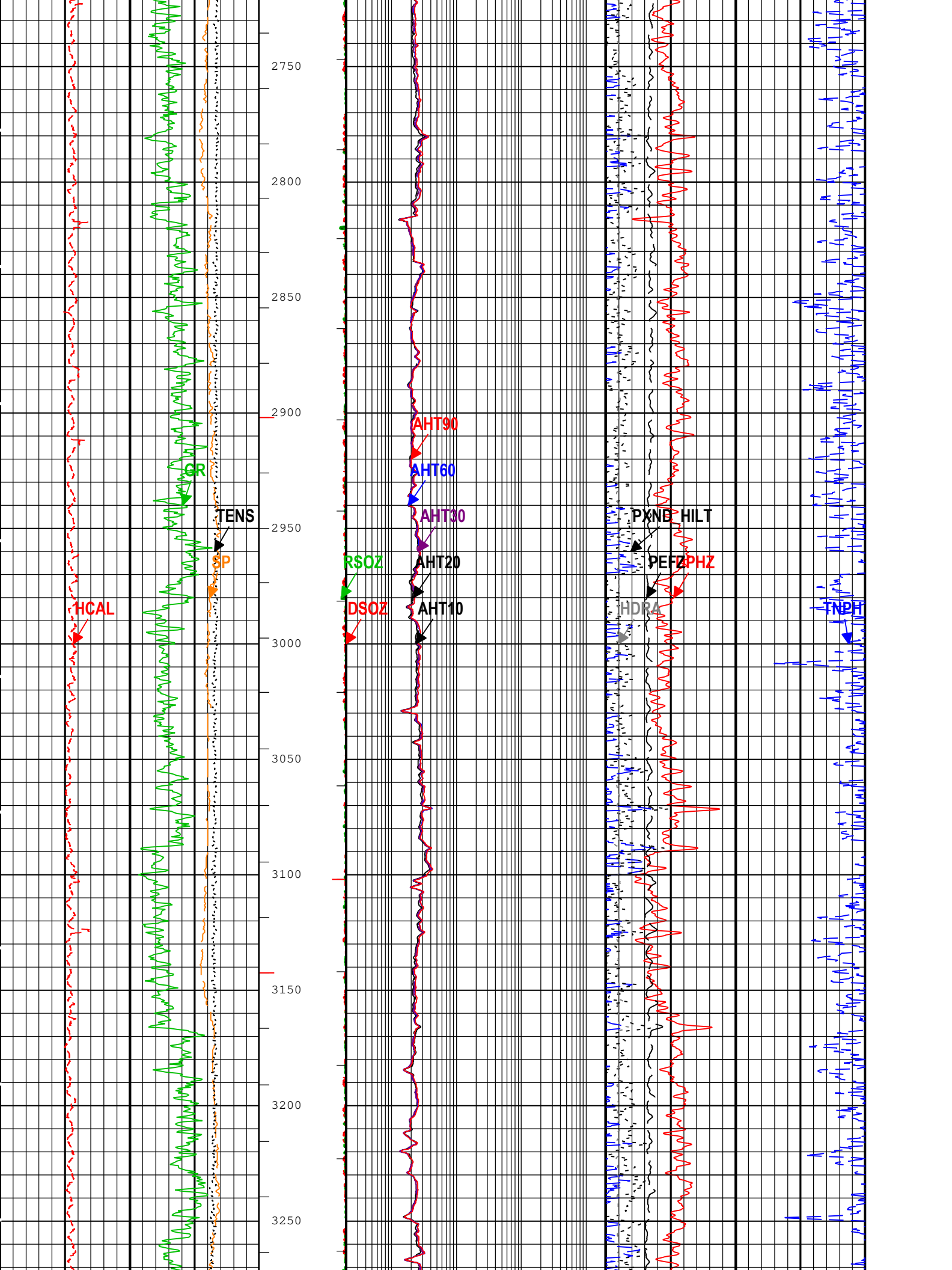
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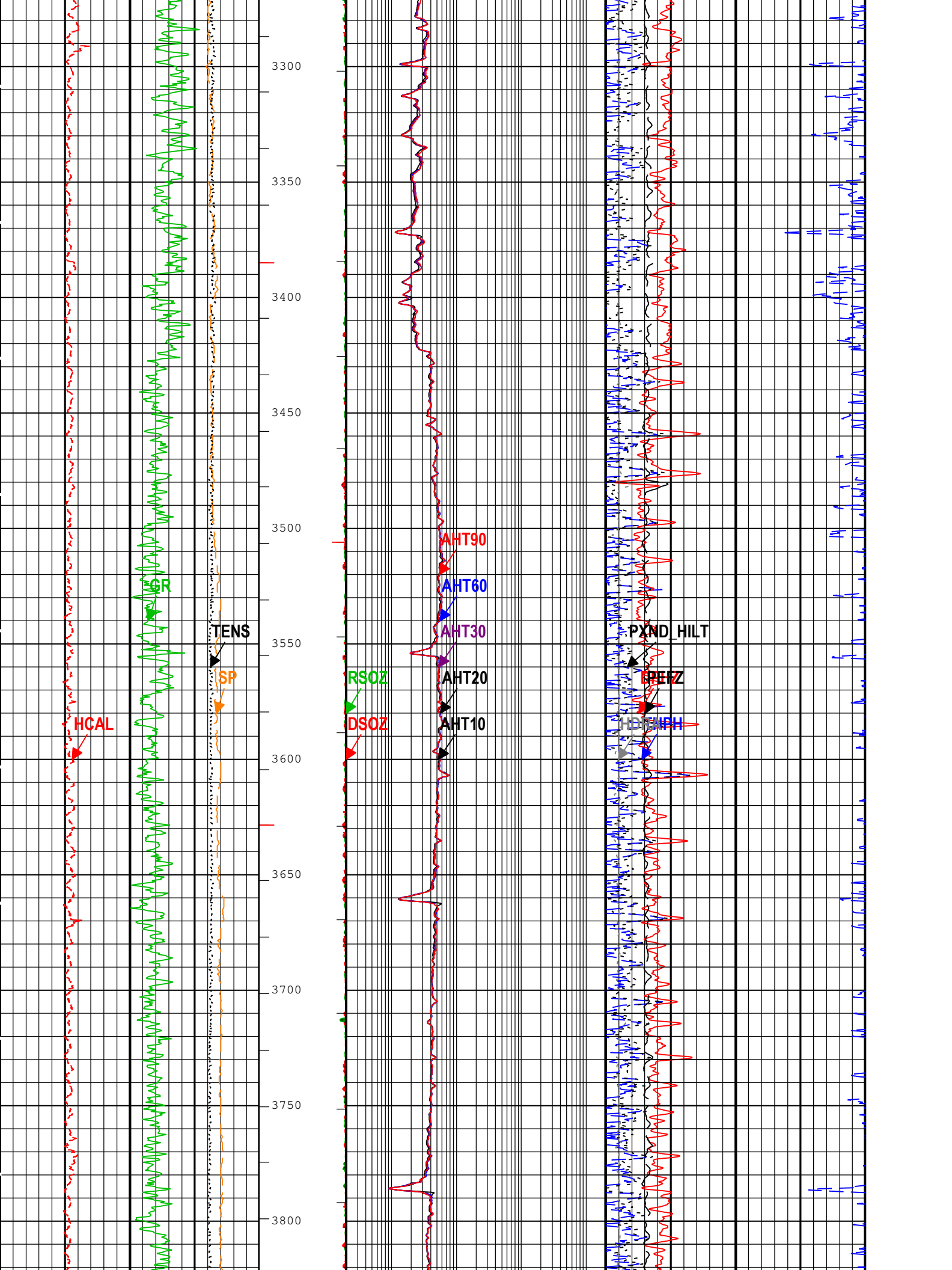
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DSOZ
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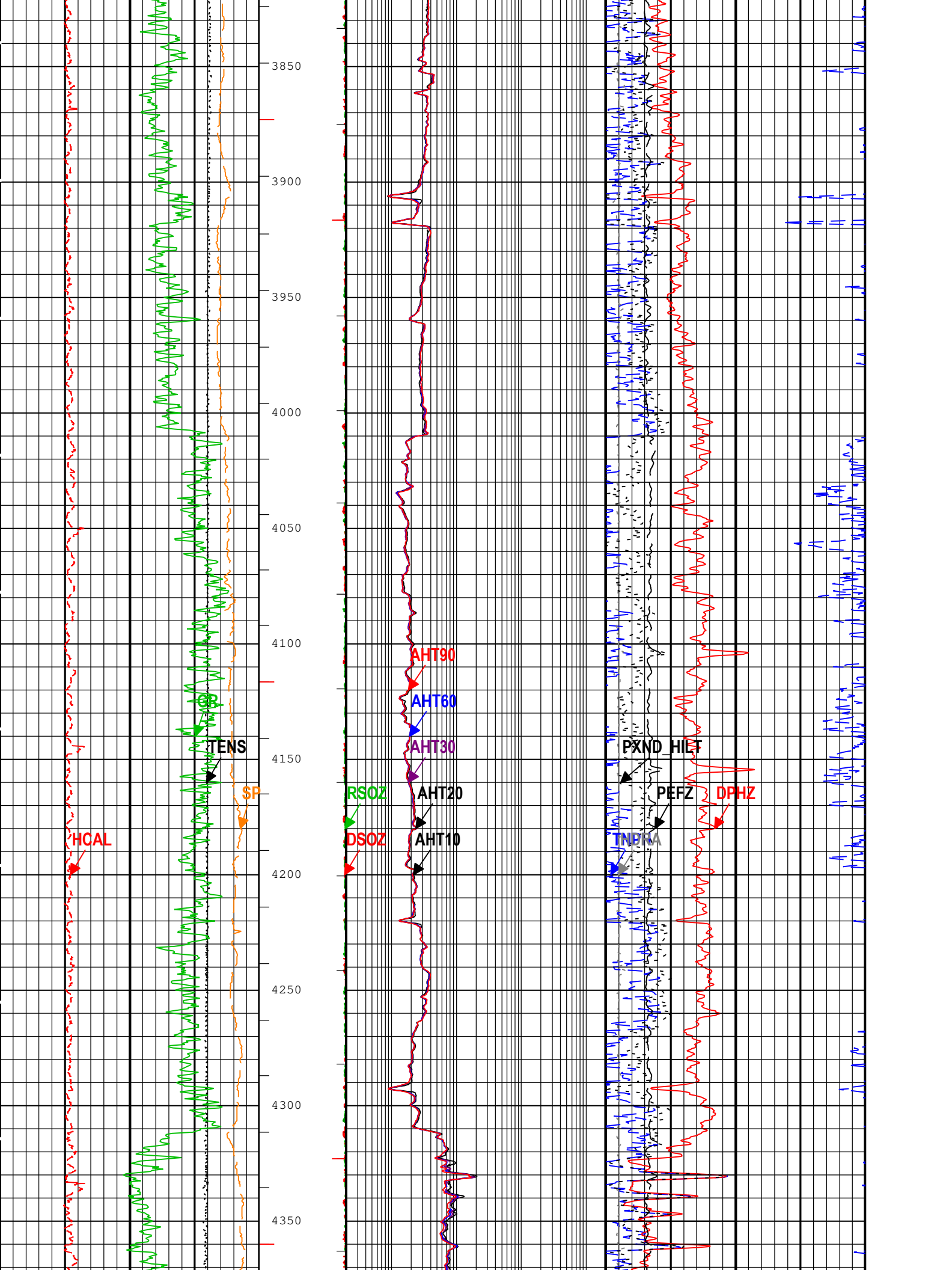
PXND_HILT
DPEFZ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DPHZ
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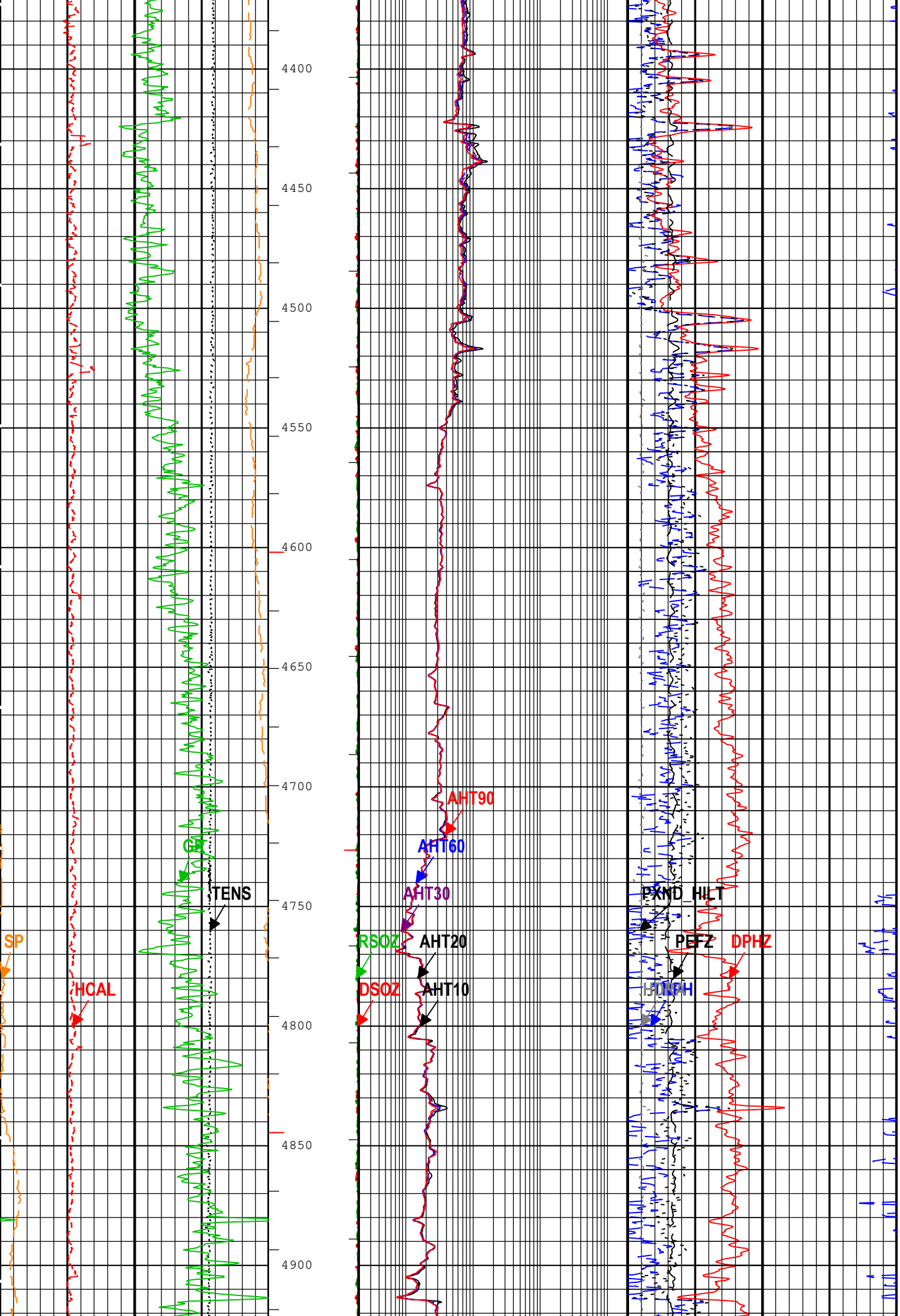
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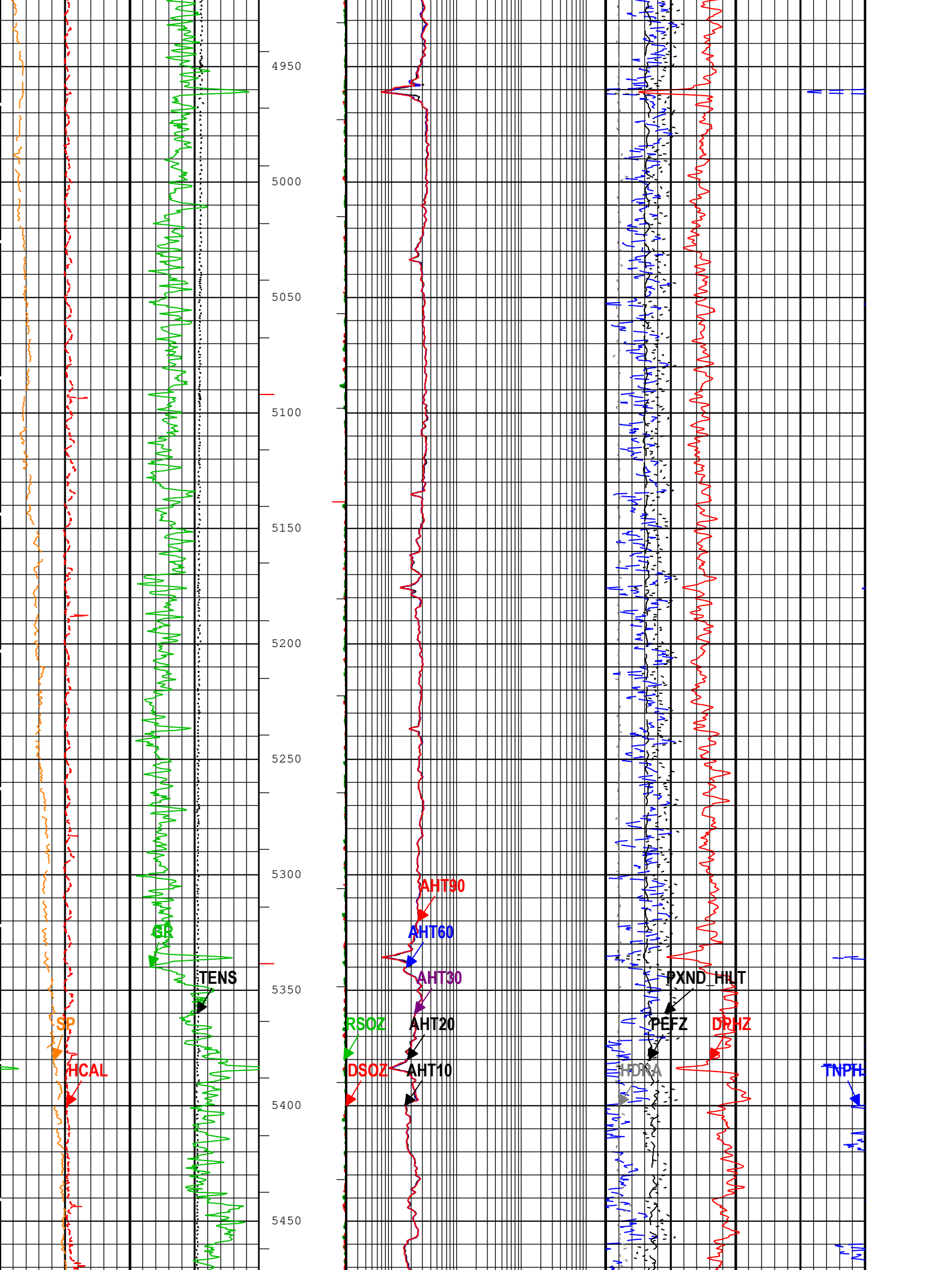
DPHZ
HDNPH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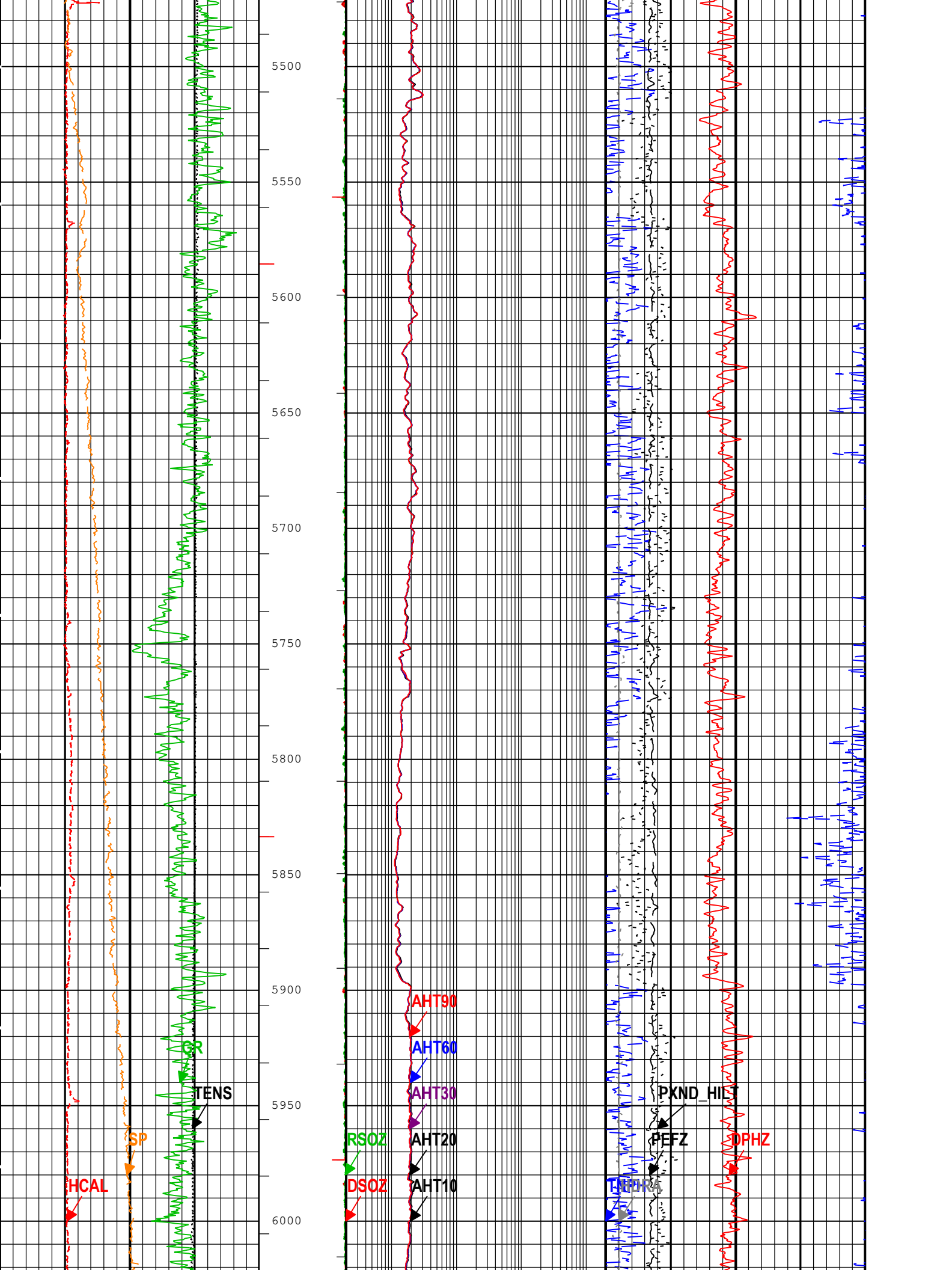
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6000
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SP
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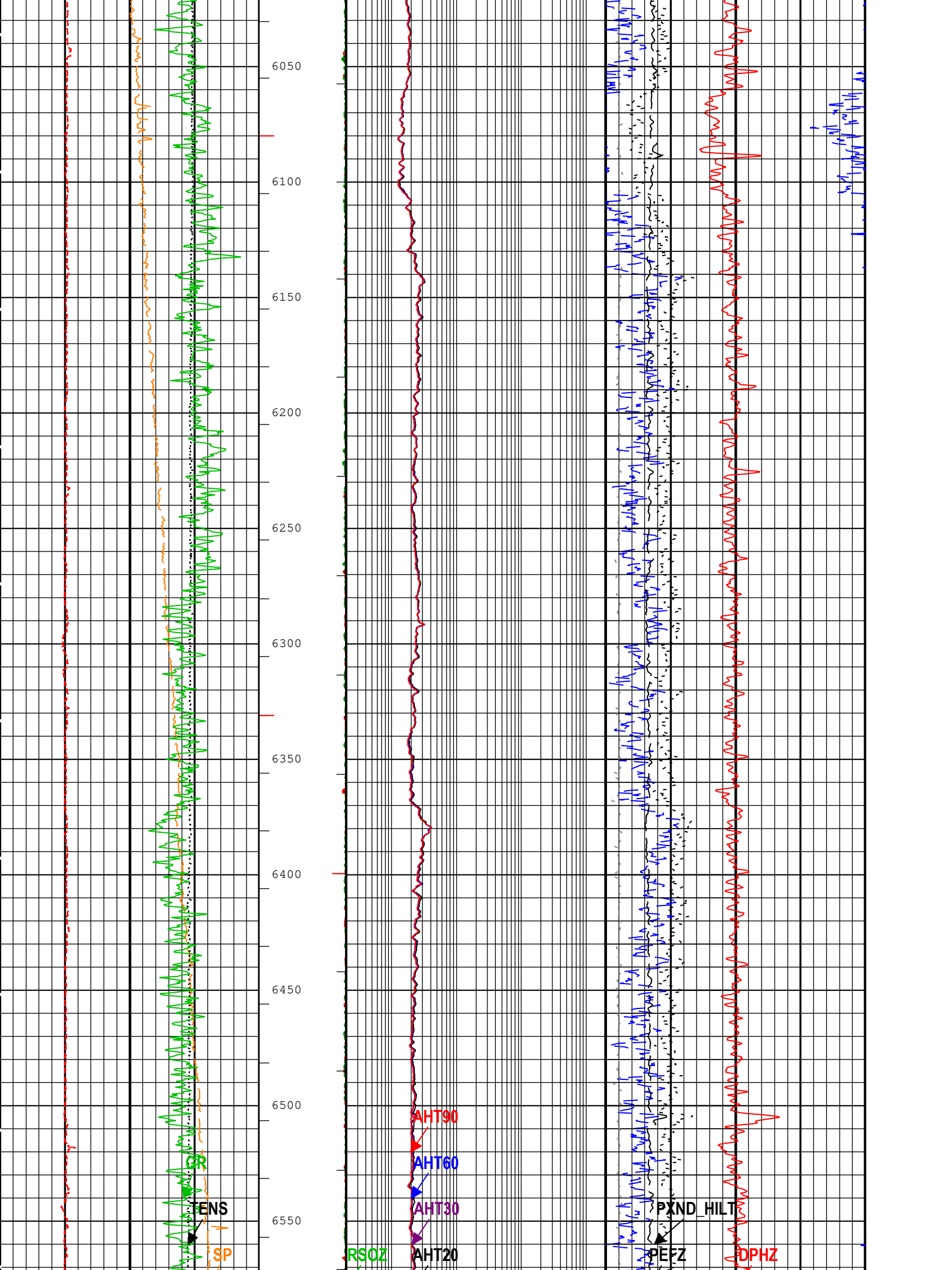
PEFZ
DPHZ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SP
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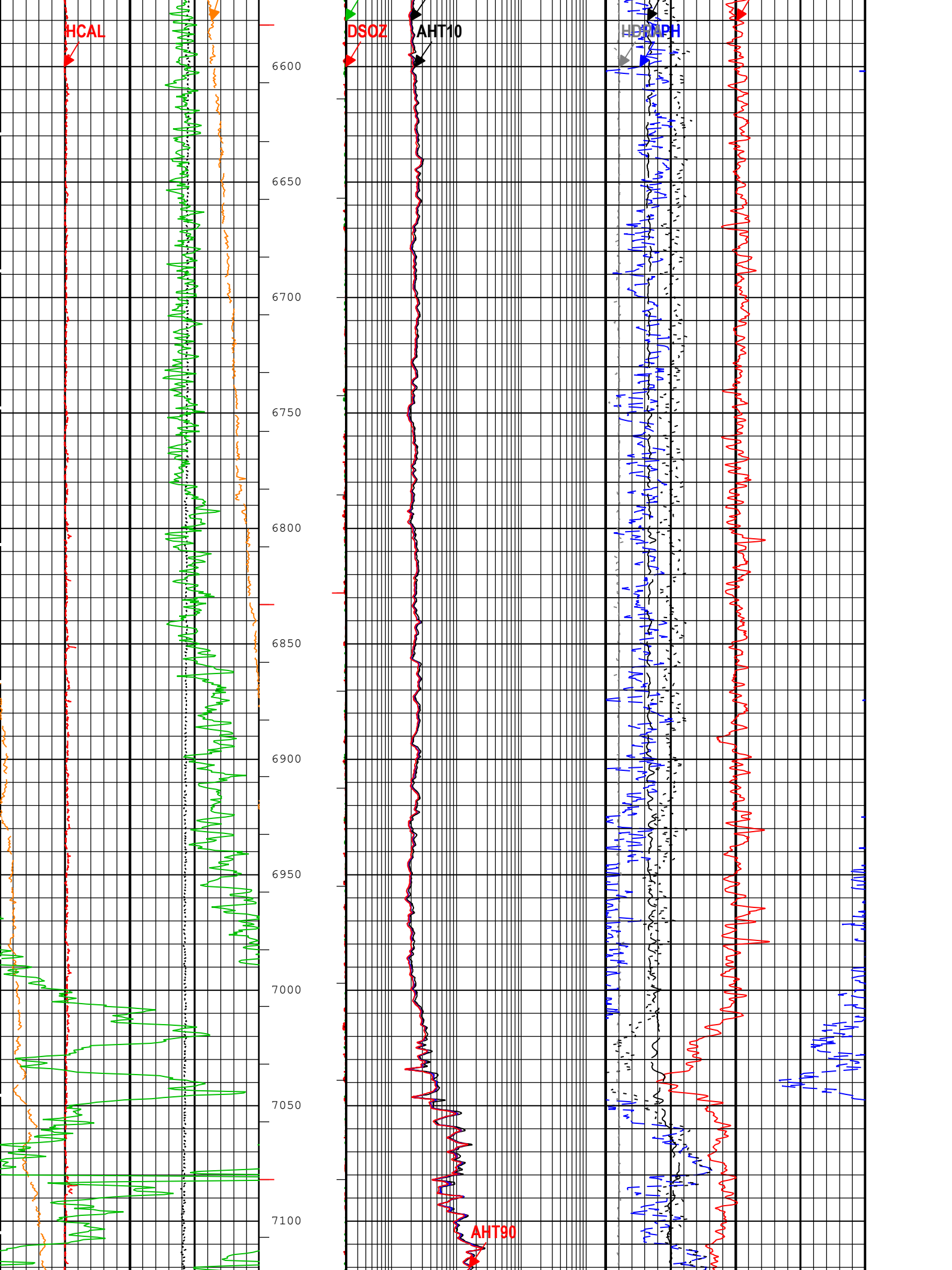
PEFZ
DPHZ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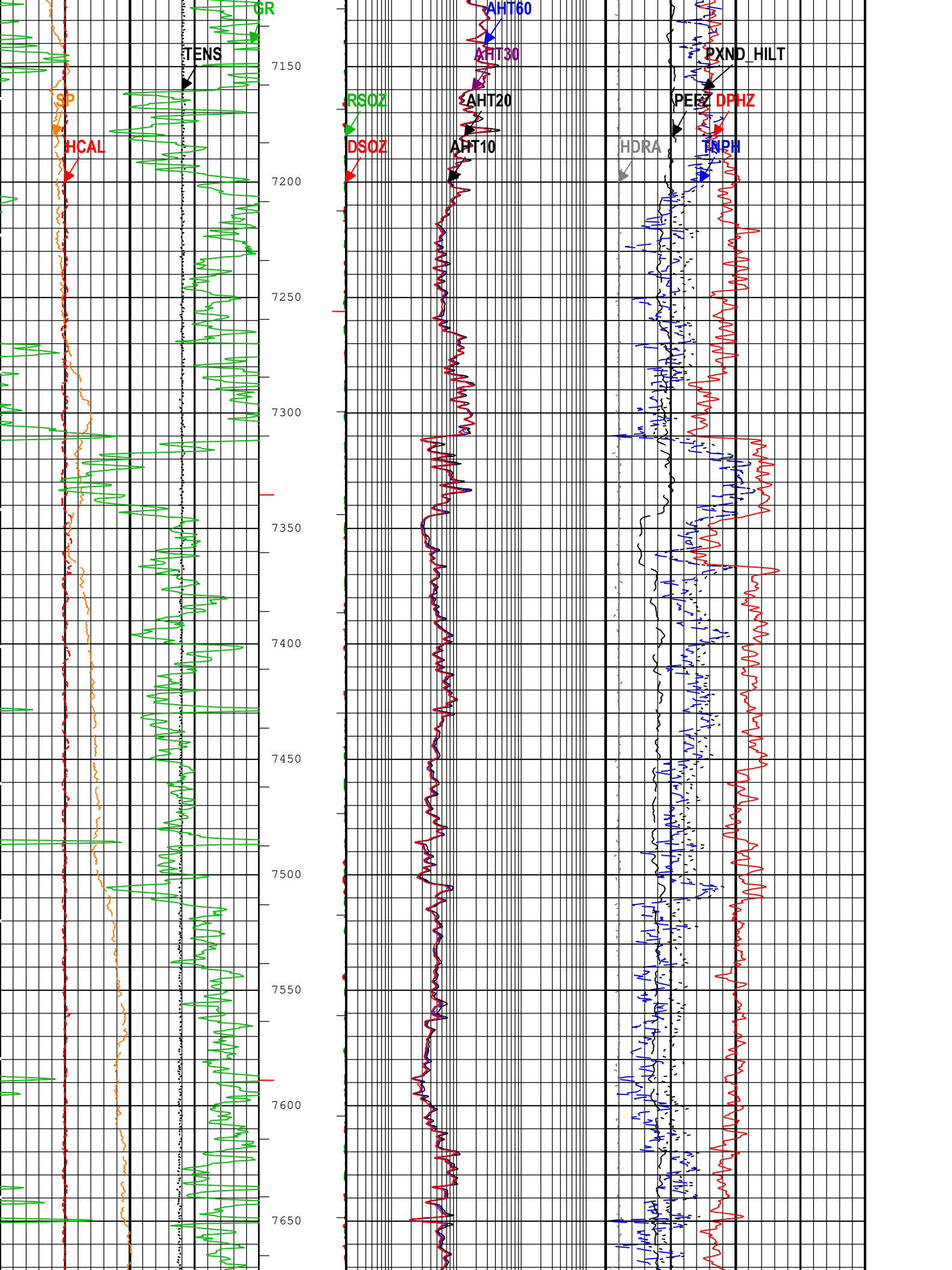
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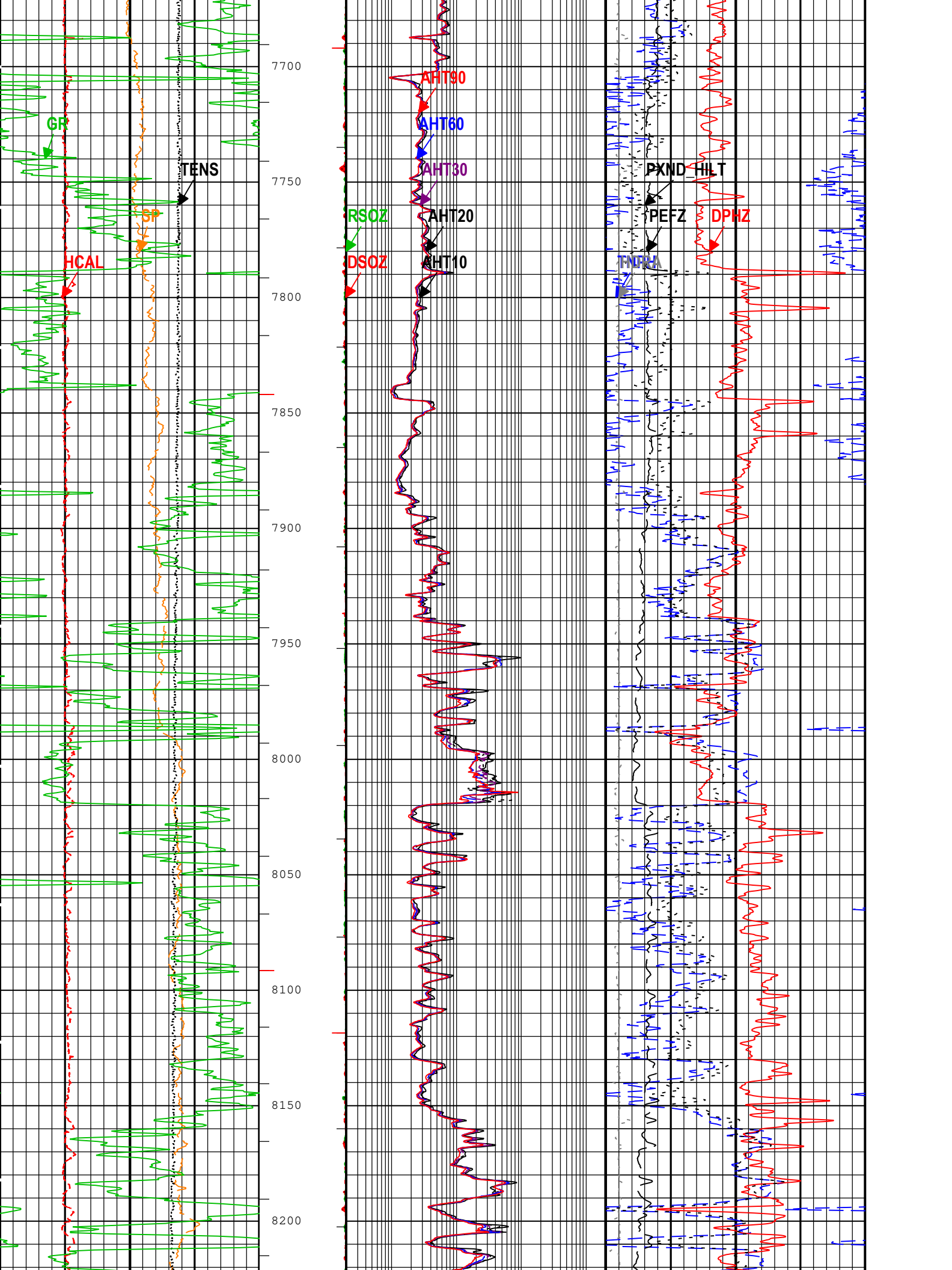
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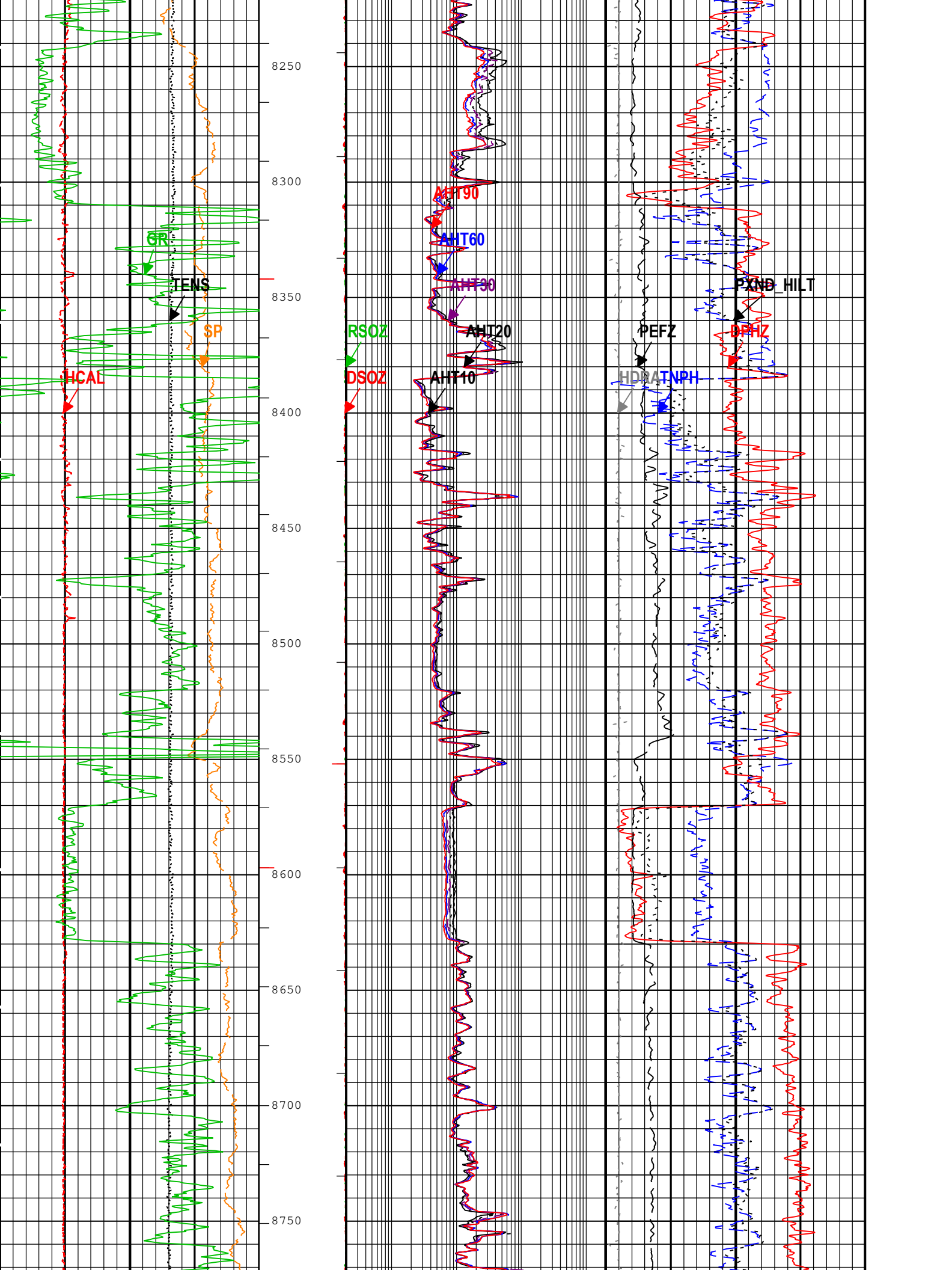
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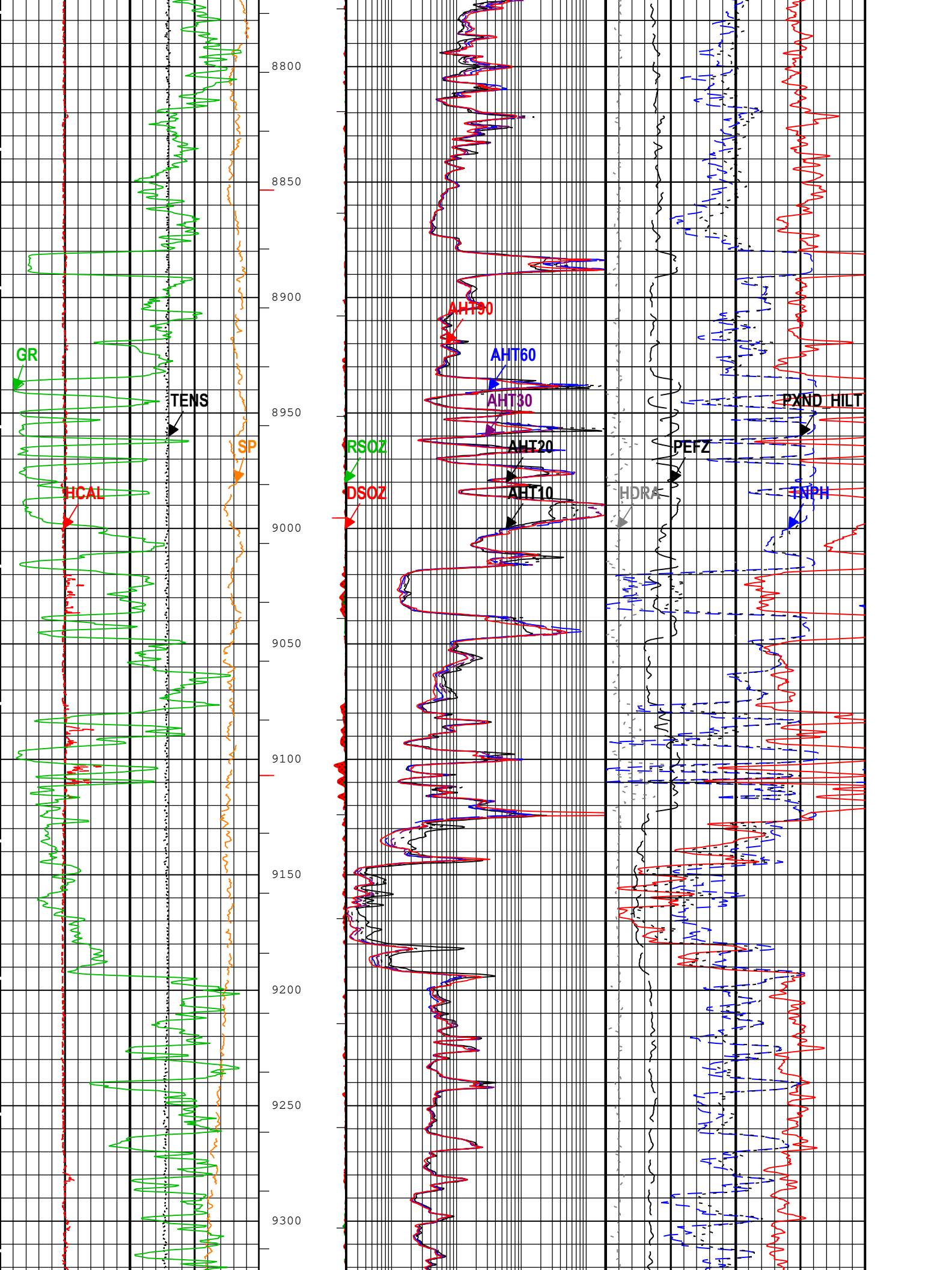
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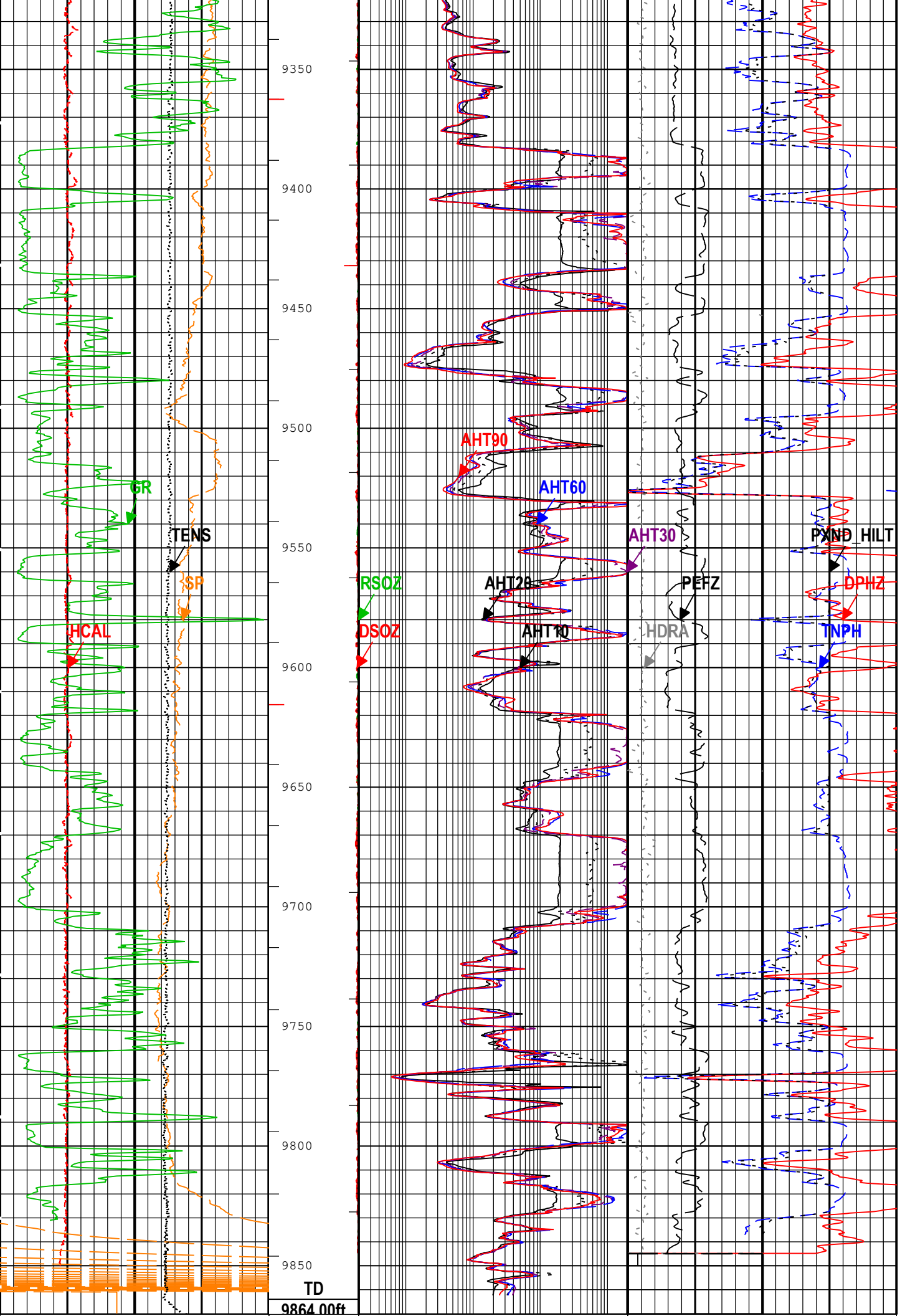
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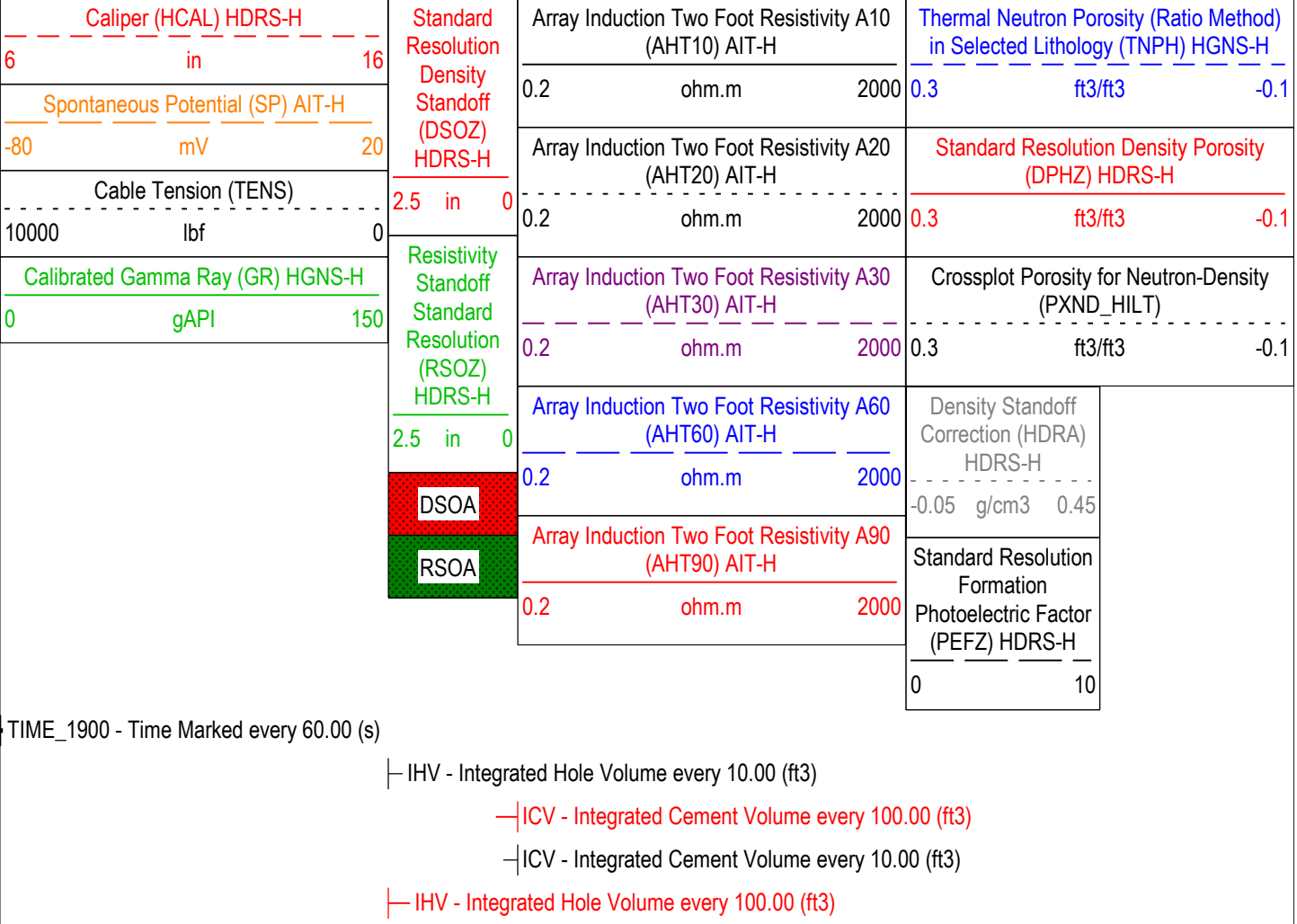



Description: Triple Combo standard resolution template for Platform Express Format: Log ( TCOM 2in ) Index Scale: 2 in per 100 ft Index Unit: ft Index Type: Measured Depth Creation Date: 24-Feb-2023 02:44:15

# 1A

## Main Pass 5" = 100'

## Integration Summary

| Output Channel(s) | Output Description | Input Parameter | Output Value | Unit |
|---|---|---|---|---|
| IHV | Integrated Hole Volume | GCSE_UP_PASS | 3376.66 | ft3 |
| ICV | Integrated Cement Volume | GCSE_UP_PASS, FCD | 2004.53 | ft3 |

## Pass Summary

| Run Name | Pass Objective | Direction | Top | Bottom | Start | Stop | DSC Mode | Depth Shift | Include Parallel Data |
|---|---|---|---|---|---|---|---|---|---|
| 1A | Main[3]:Up | Up | 41.16 ft | 9870.33 ft | 23-Feb-2023 11:36:23 PM | 24-Feb-2023 2:35:46 AM | ON | 3.80 ft | Yes |

All depths are referenced to toolstring zero

## Log

Company:TALLGRASS HIGH PLAINS CARBON STORAGE, LLC Well:Juniper M-1

1A: Main[3]:Up:S009

Description: Triple Combo standard resolution template for Platform Express Format: Log ( TCOM 5in ) Index Scale: 5 in per 100 ft Index Unit: ft Index Type: Measured Depth Creation Date: 24-Feb-2023 02:44:22

| Channel | Source | Sampling |
|---|---|---|
| AT10 | AIT-H:AHIS:AHIS | 3in |
| AT20 | AIT-H:AHIS:AHIS | 3in |
| AT30 | AIT-H:AHIS:AHIS | 3in |
| AT60 | AIT-H:AHIS:AHIS | 3in |
| AT90 | AIT-H:AHIS:AHIS | 3in |
| CALI | HDRS-H:HRCC-H:HRCC-H | 1in |
| DPHZ | HDRS-H:HRMS-H:HRCP-H | 3in |

| | | |
|---|---|---|
| DPHZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| DSOZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| GR_CAL | HGNS-H:HGNS-H:HGNS-H | 6in |
| HDRA | HDRS-H:HRMS-H:HRGD-H | 2in |
| ICV | Borehole | 6in - RT |
| IHV | Borehole | 6in - RT |
| PEFZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| PXND | PEQL | 6in |
| RSOZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| SP | AIT-H:AHIS:AHIS | 6in |
| TENS | WLWorkflow | 1in |
| TIME_1900 | WLWorkflow | 0.1in |
| TNPH | HGNS-H:HGNS-H:HGNS-H | 6in |

- IHV - Integrated Hole Volume every 100.00 (ft3)
  - ICV - Integrated Cement Volume every 10.00 (ft3)
  - ICV - Integrated Cement Volume every 100.00 (ft3)
- IHV - Integrated Hole Volume every 10.00 (ft3)

TIME_1900 - Time Marked every 60.00 (s)

Caliper (HCAL) HDRS-H
6 in 16

Spontaneous Potential (SP) AIT-H
-80 mV 20

Cable Tension (TENS)
10000 lbf 0

Calibrated Gamma Ray (GR) HGNS-H
0 gAPI 150

Standard Resolution Density Standoff (DSOZ) HDRS-H
2.5 in 0

DSOA

RSOA

Resistivity Standoff Standard Resolution (RSOZ) HDRS-H
2.5 in 0

Array Induction Two Foot Resistivity A10 (AHT10) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A20 (AHT20) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A30 (AHT30) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A60 (AHT60) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A90 (AHT90) AIT-H
0.2 ohm.m 2000

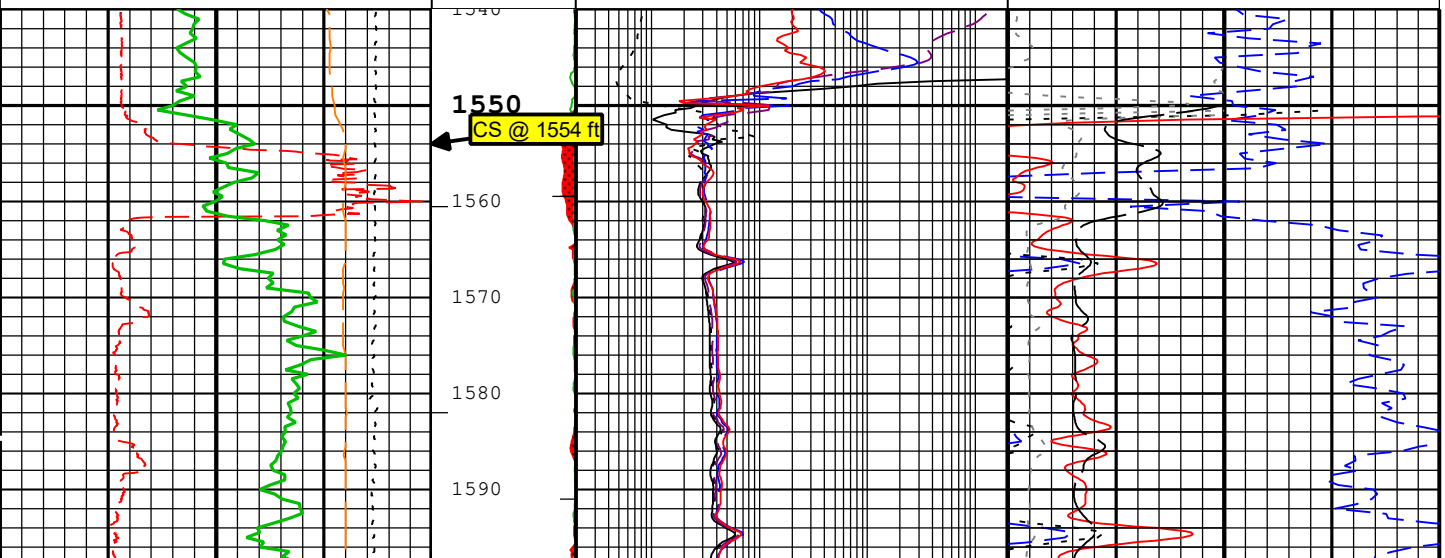
Density Standoff Correction (HDRA) HDRS-H
-0.05 g/cm3 0.45

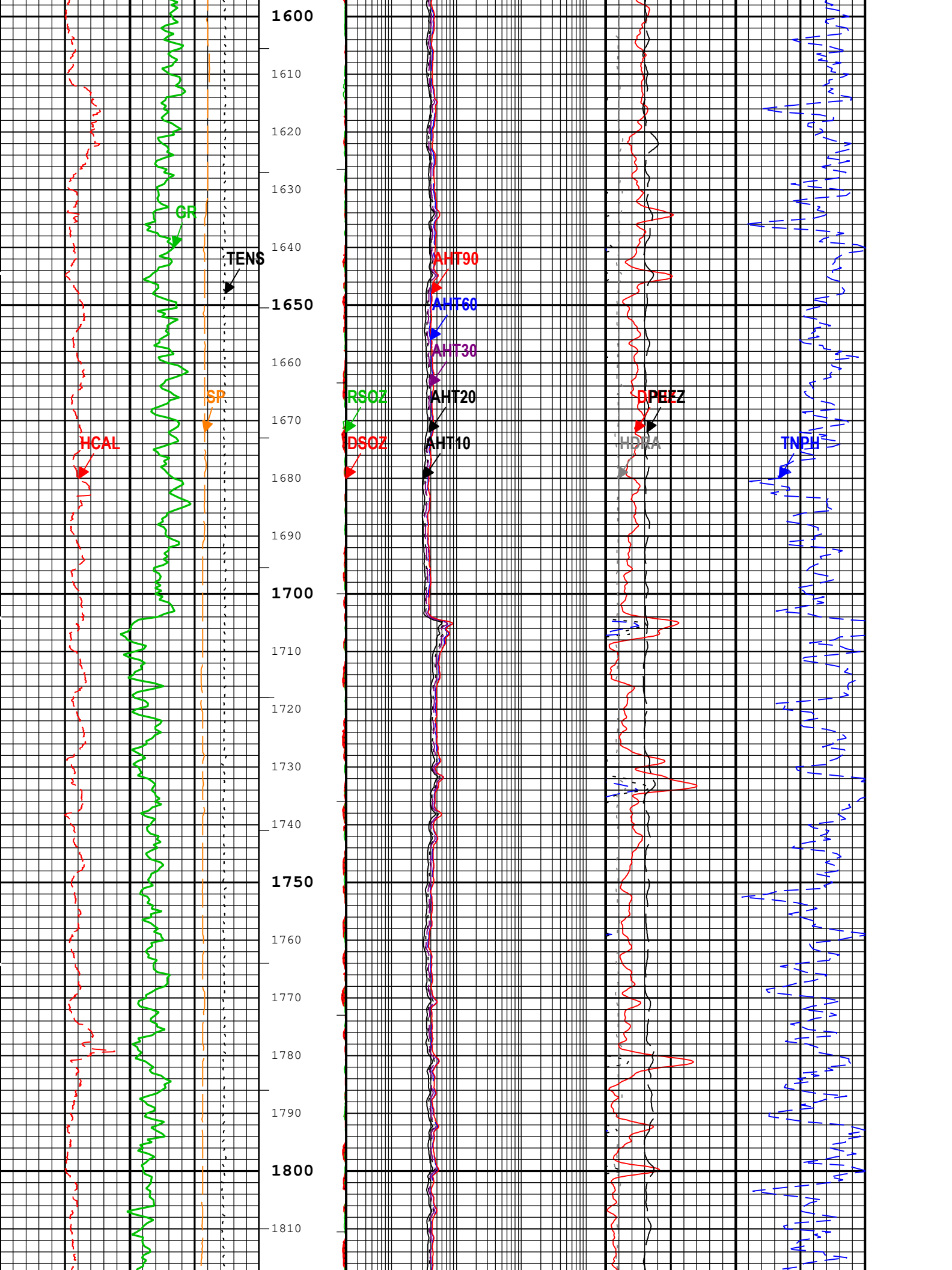
Standard Resolution Formation Photoelectric Factor (PEFZ) HDRS-H
0 10

Thermal Neutron Porosity (Ratio Method) in Selected Lithology (TNPH) HGNS-H
0.3 ft3/ft3 -0.1

Standard Resolution Density Porosity (DPHZ) HDRS-H
0.3 ft3/ft3 -0.1

Crossplot Porosity for Neutron-Density (PXND_HILT)
0.3 ft3/ft3 -0.1

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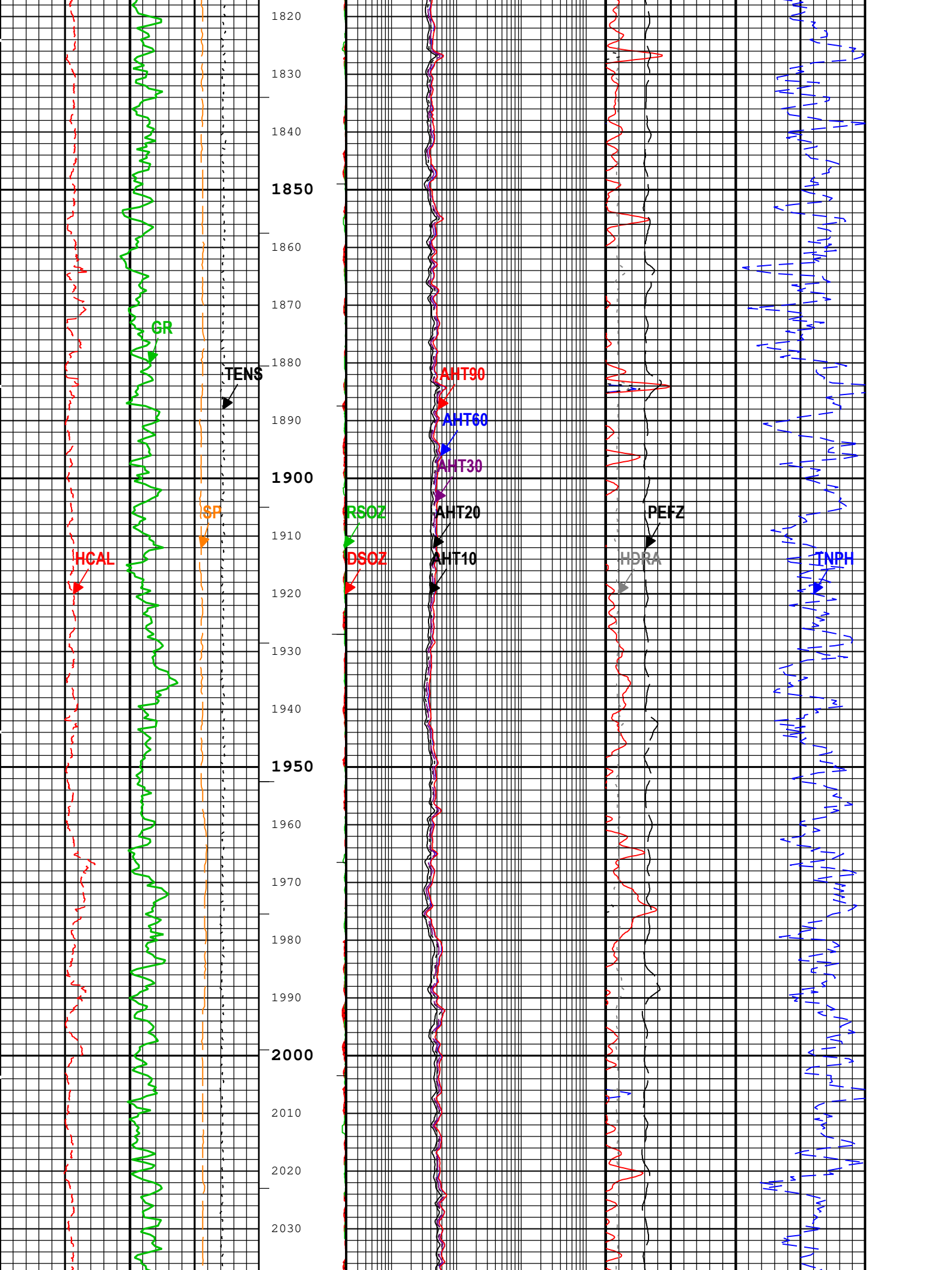
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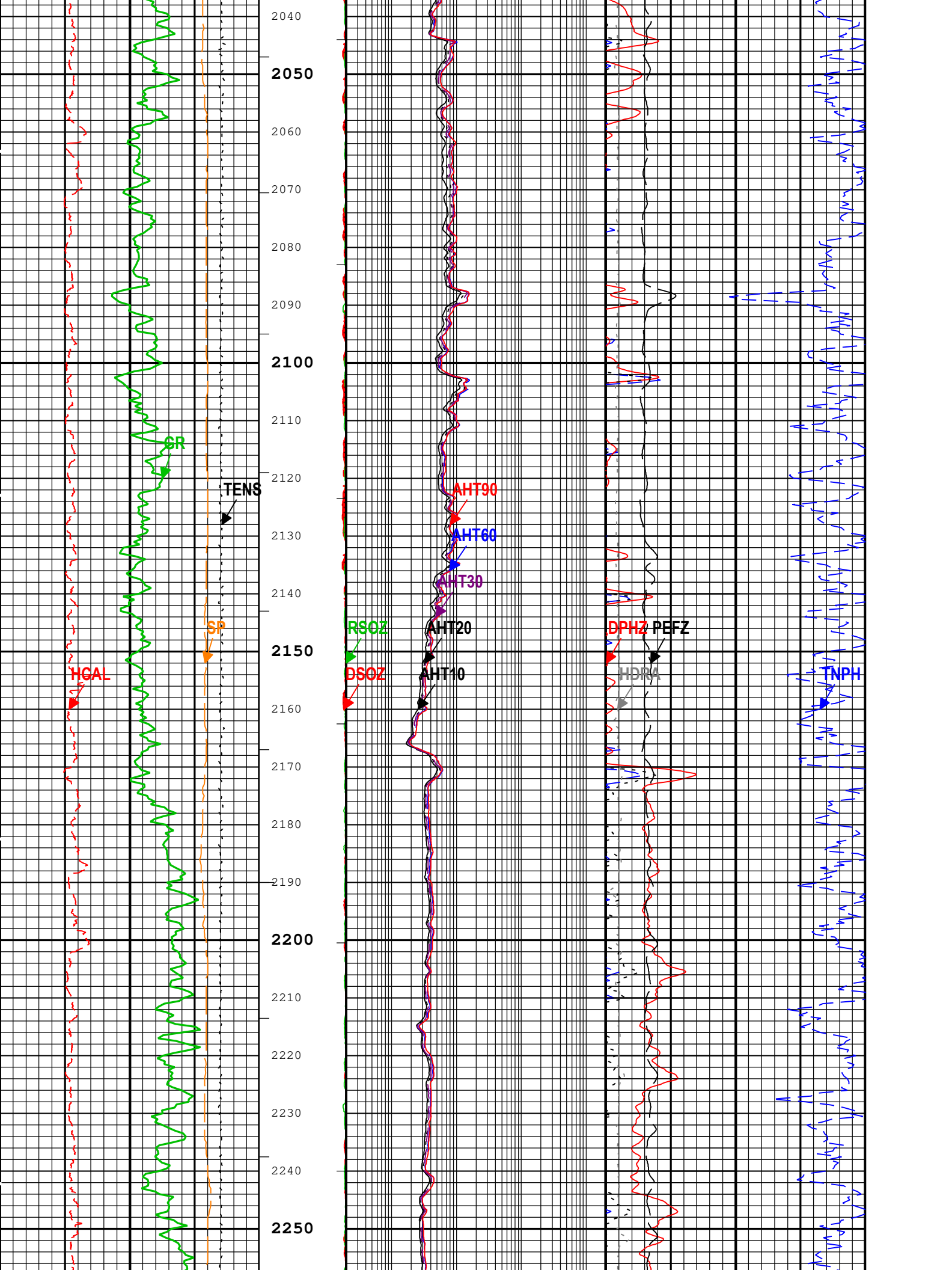
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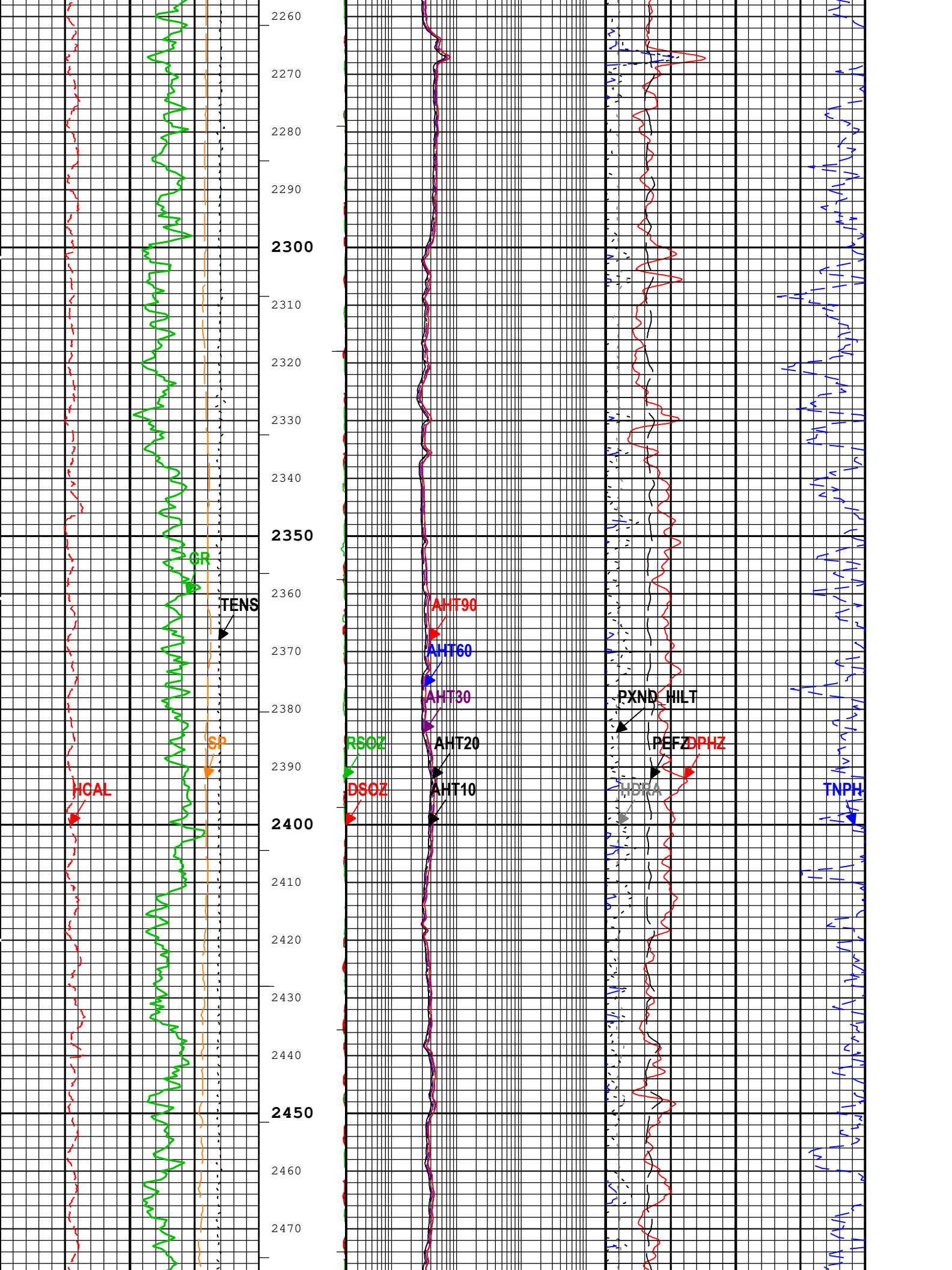
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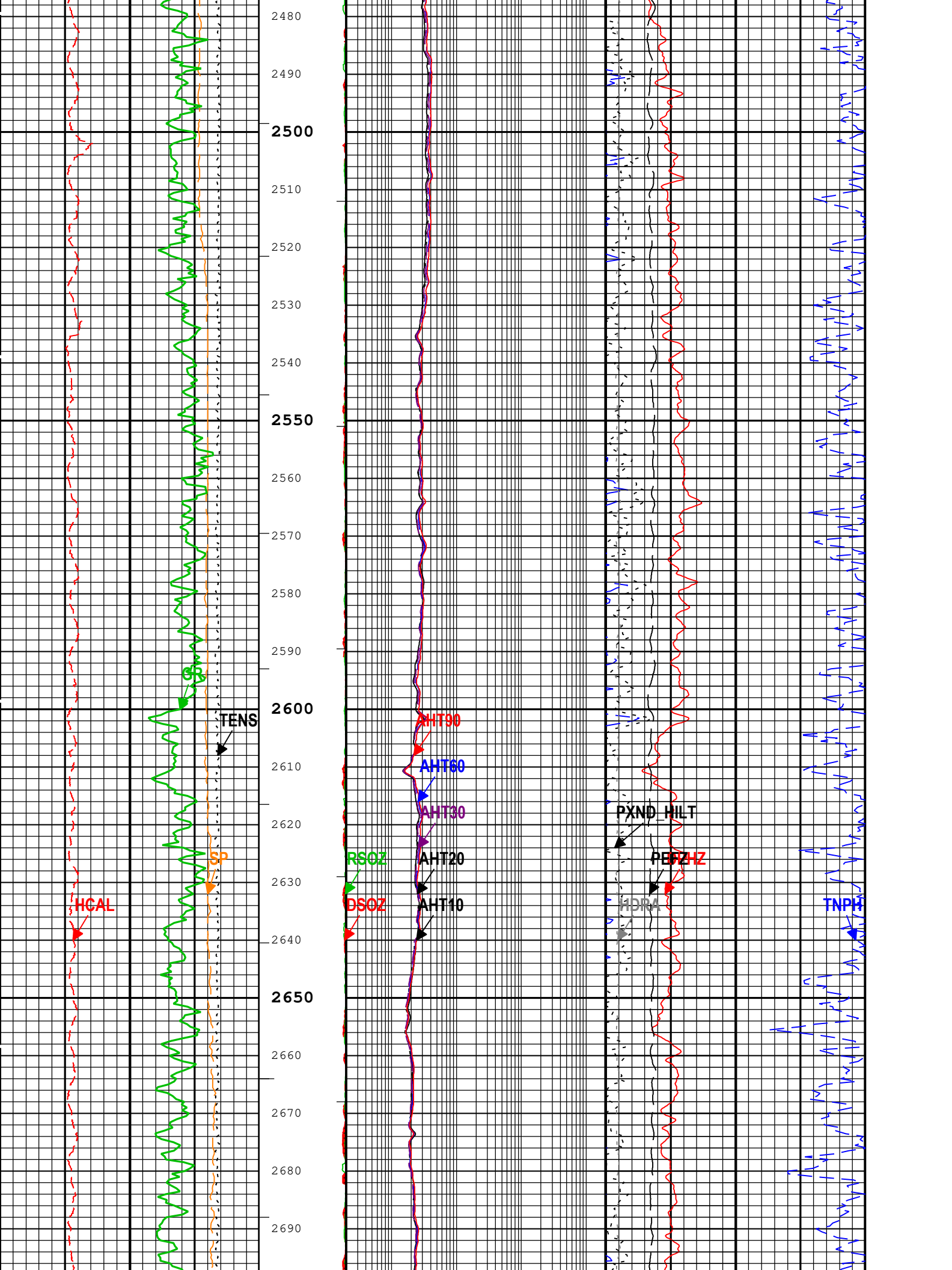
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GR
TENS
SP
HCAL
AHT90
AHT60
AHT30
AHT20
AHT10
RSOZ
DSOZ
PXND_HILT
PEFZ
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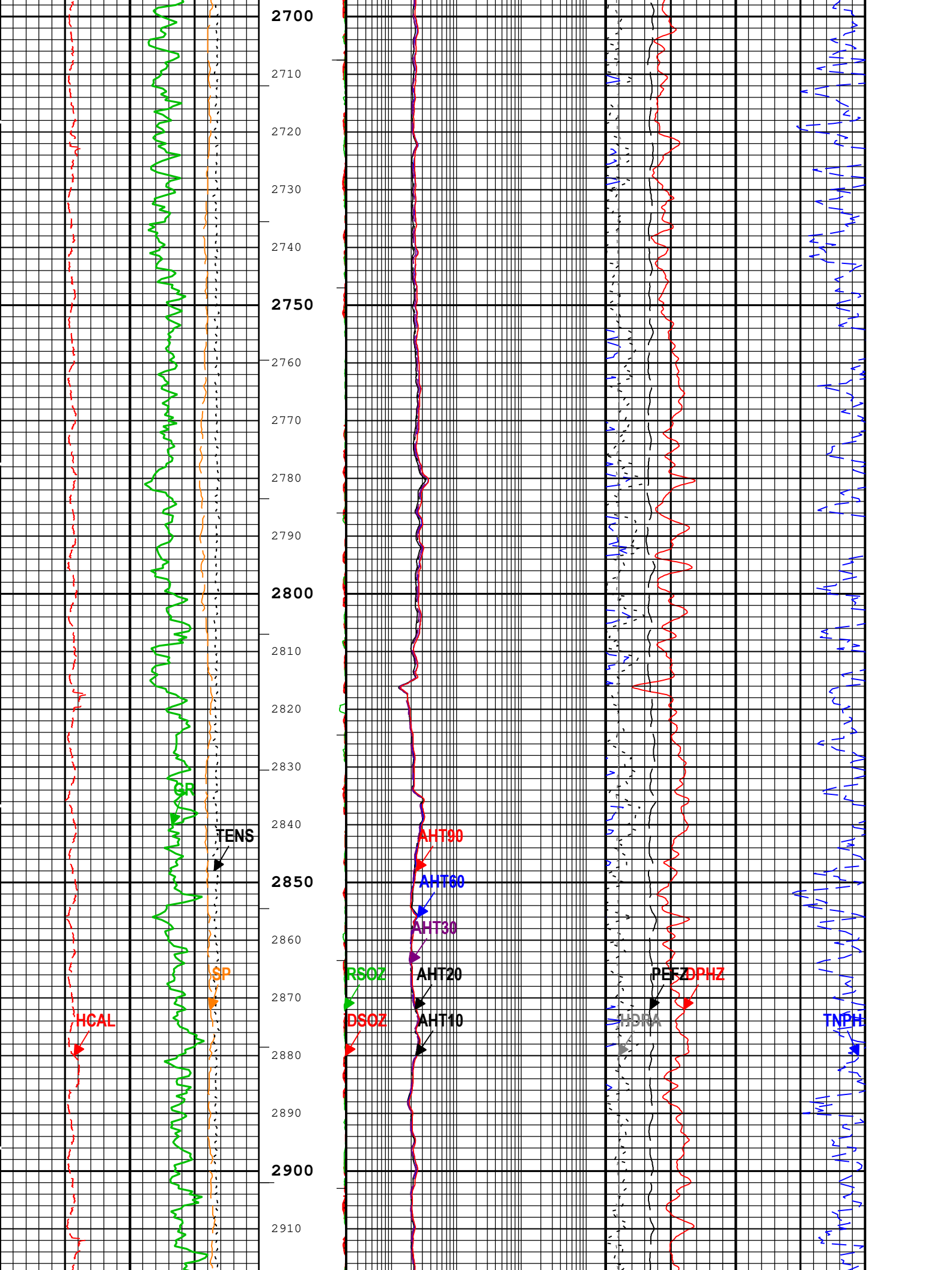
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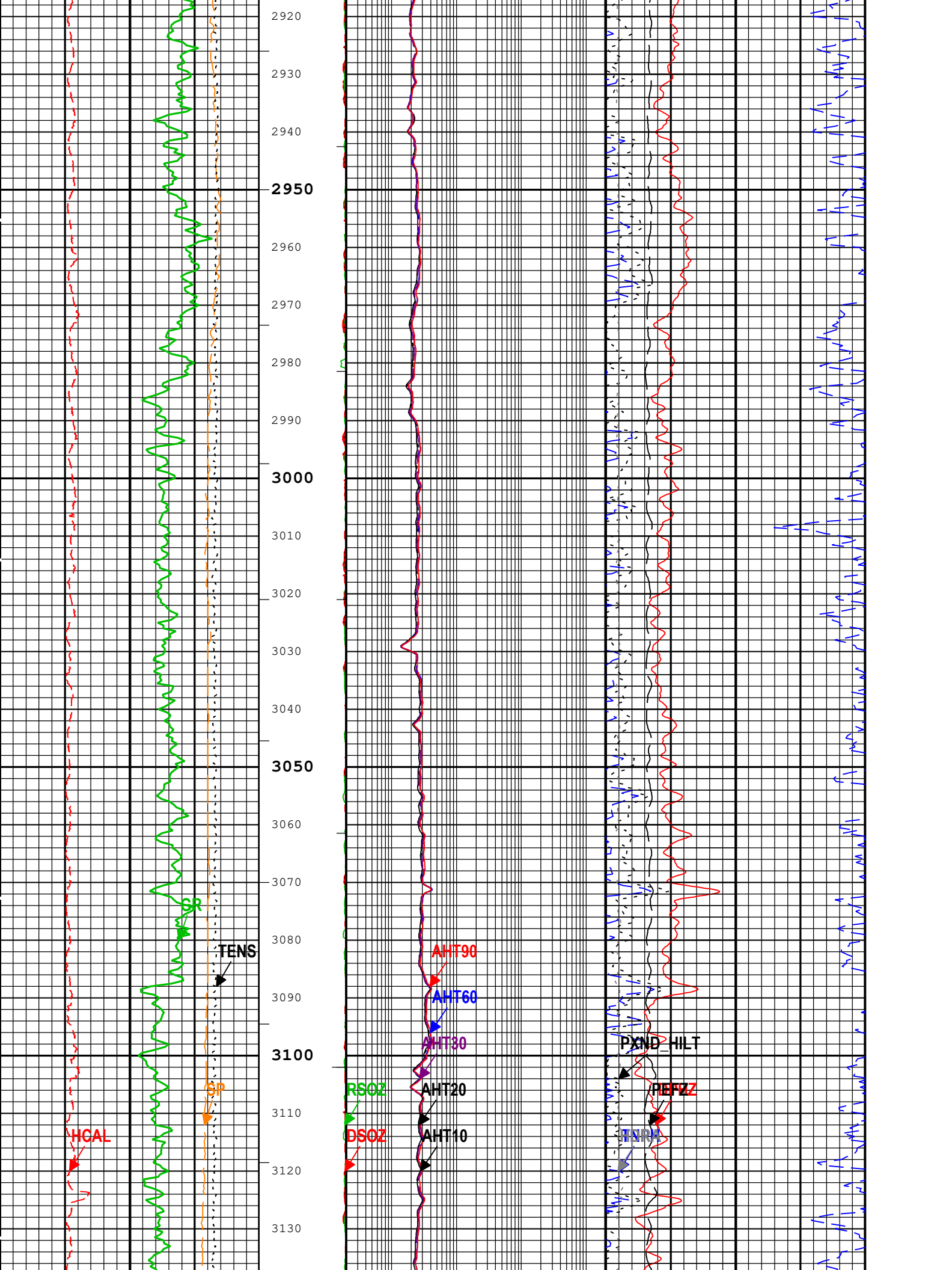
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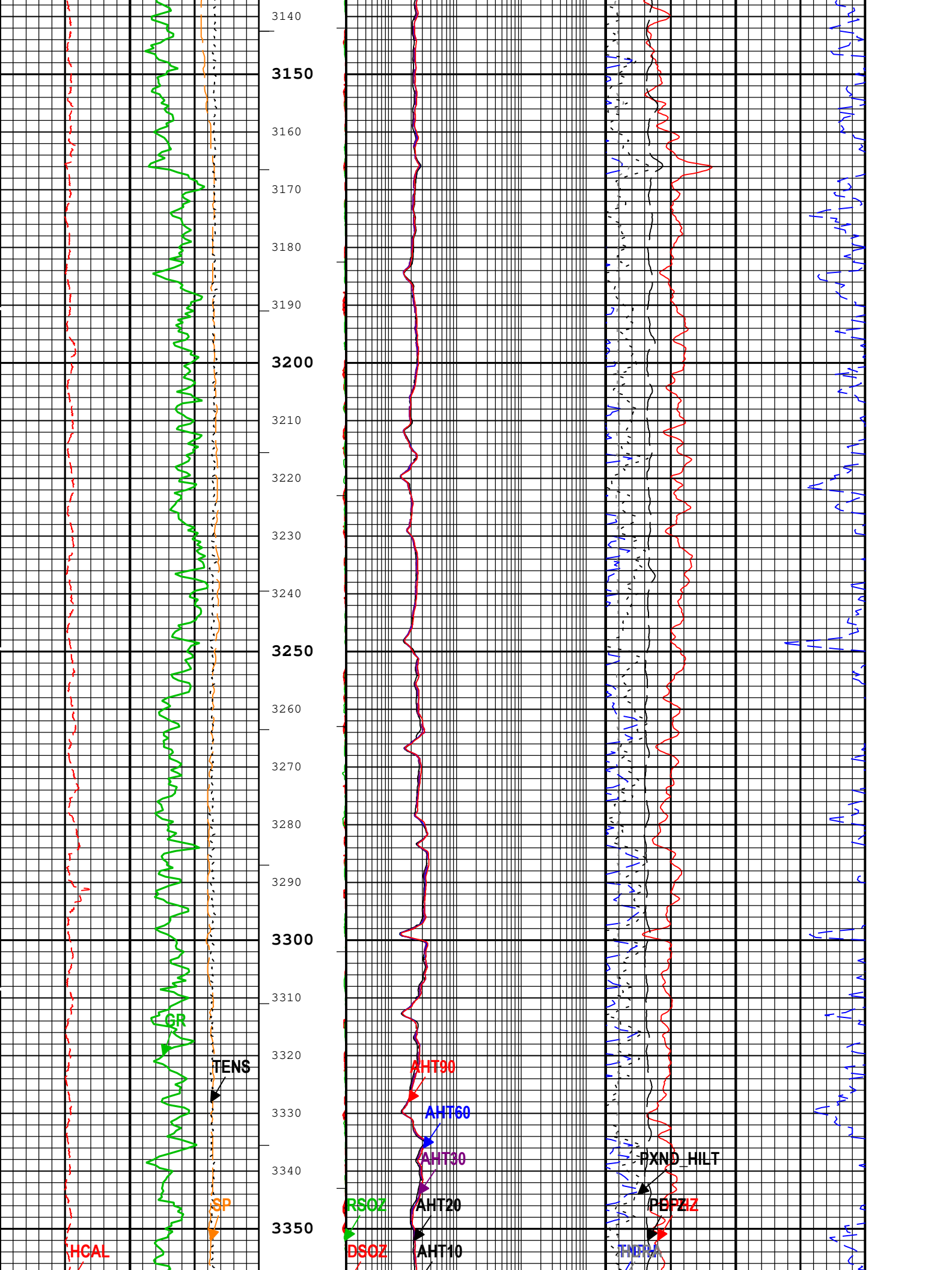
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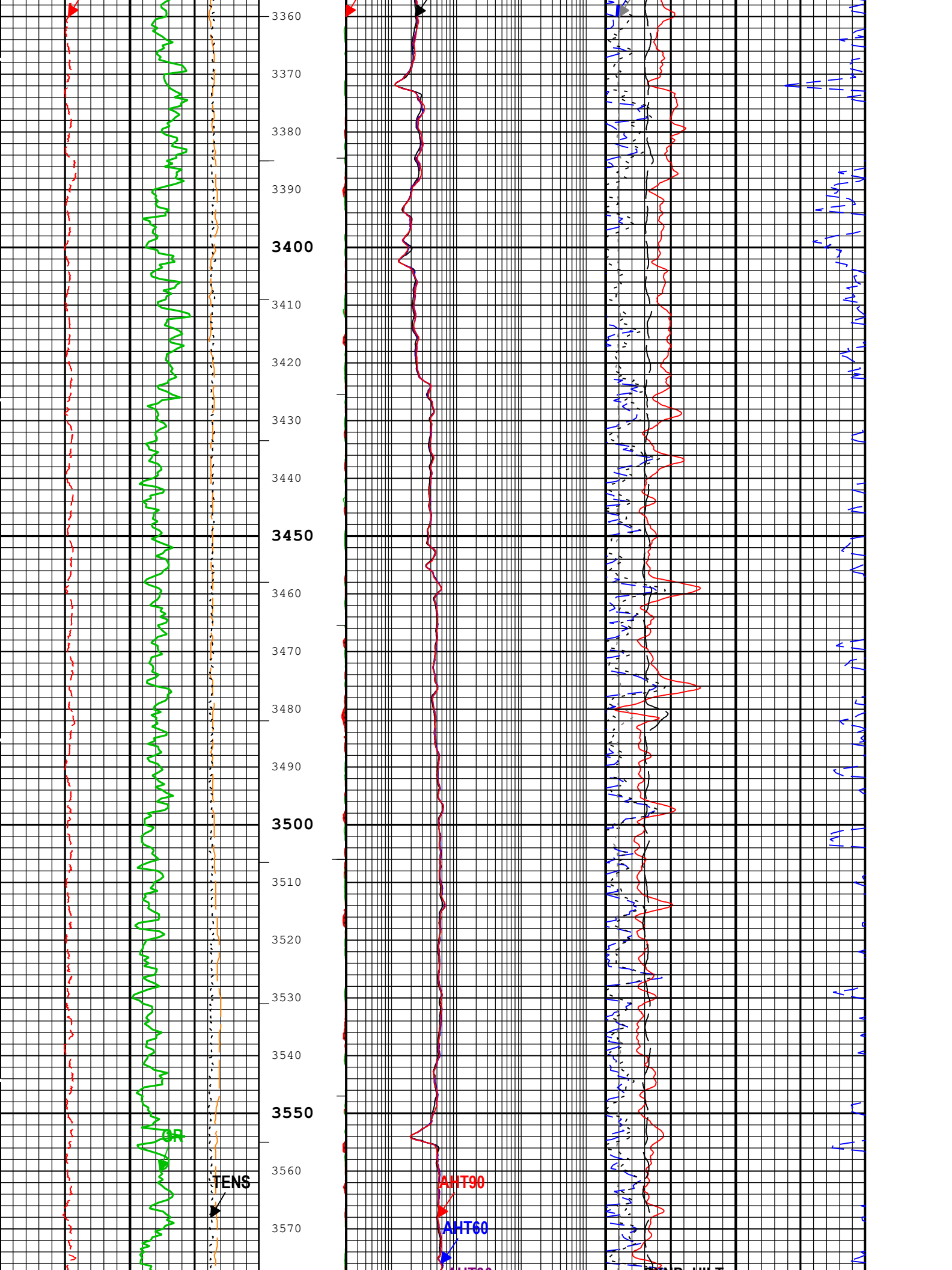
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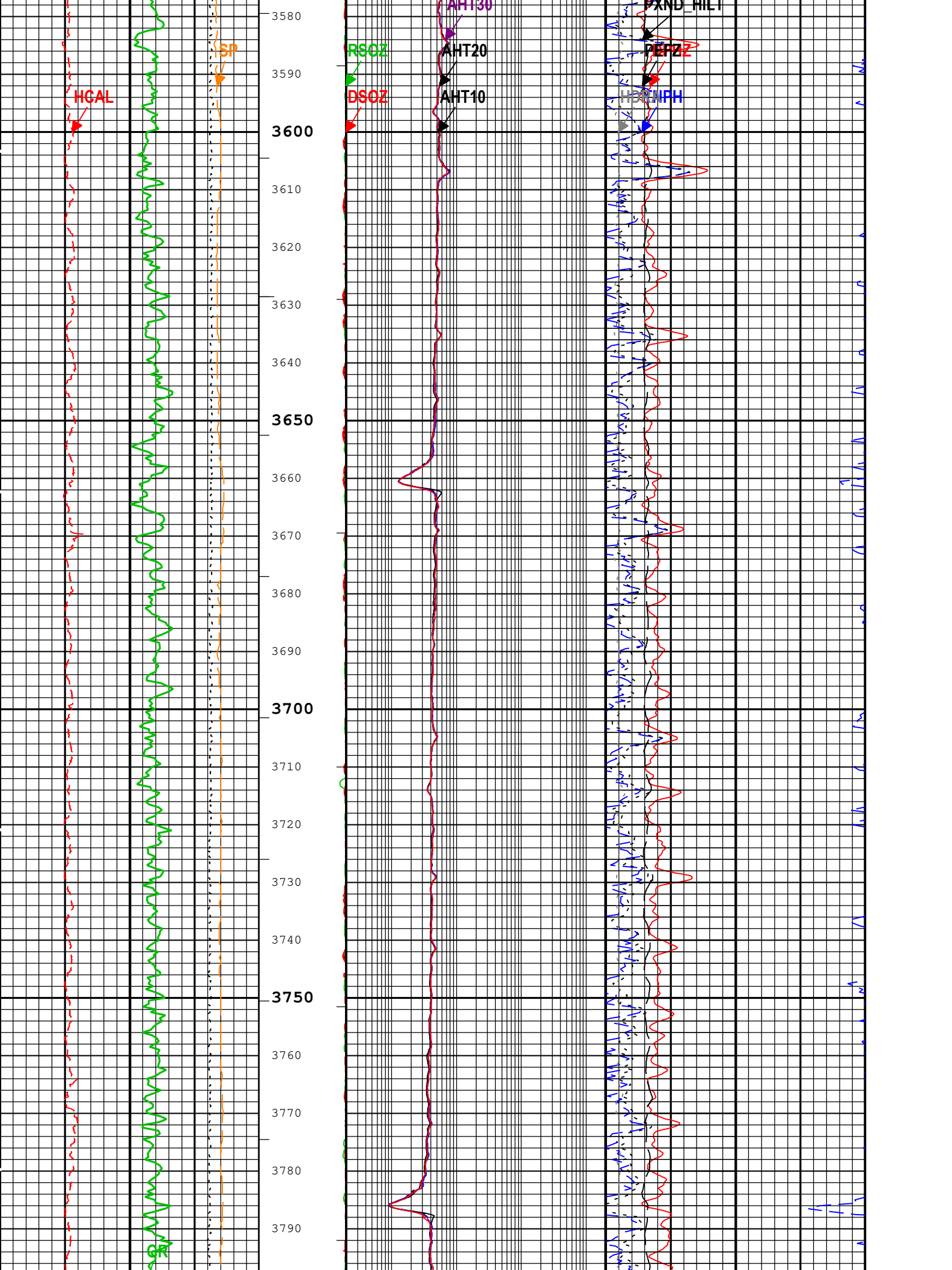
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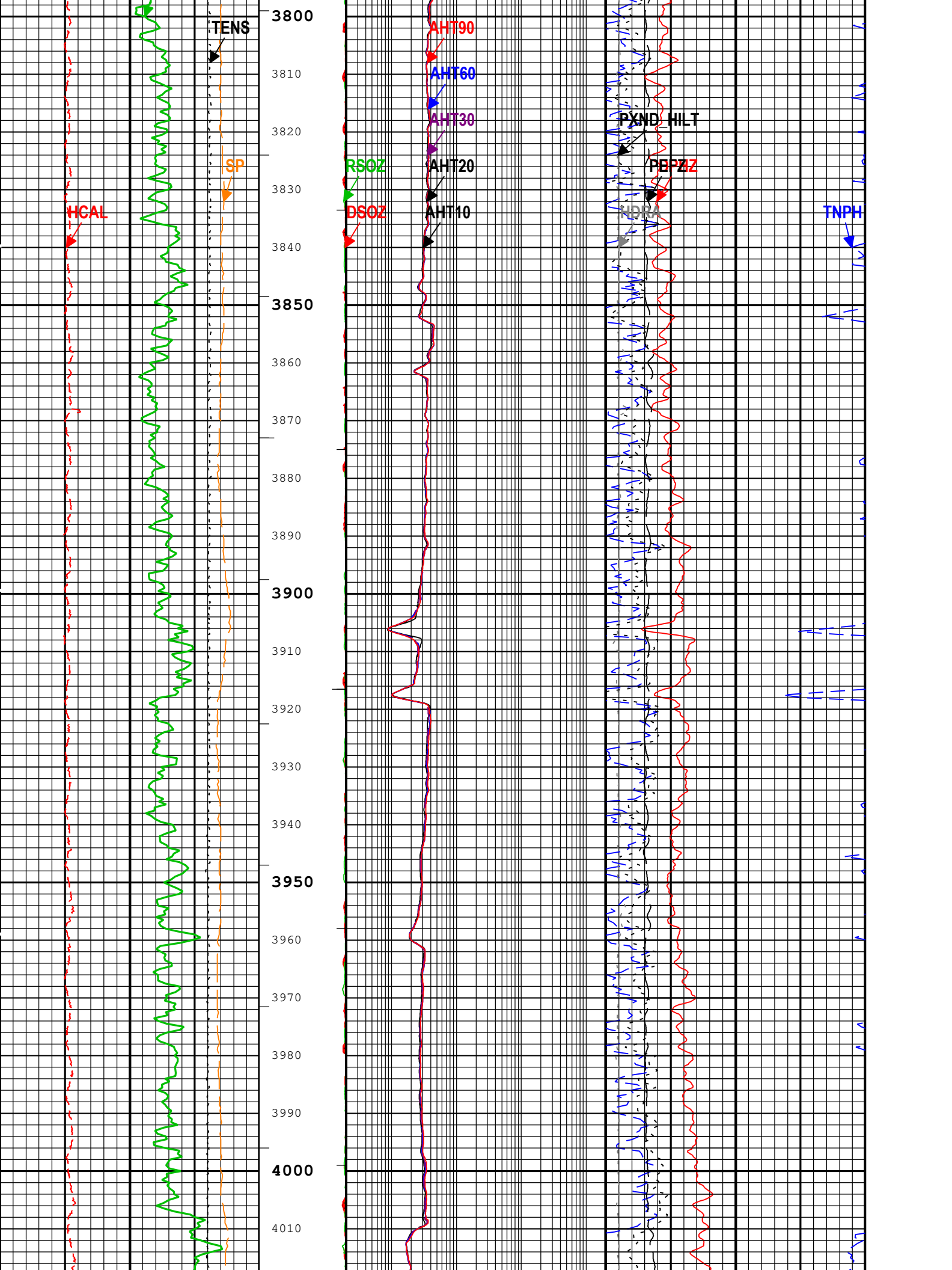
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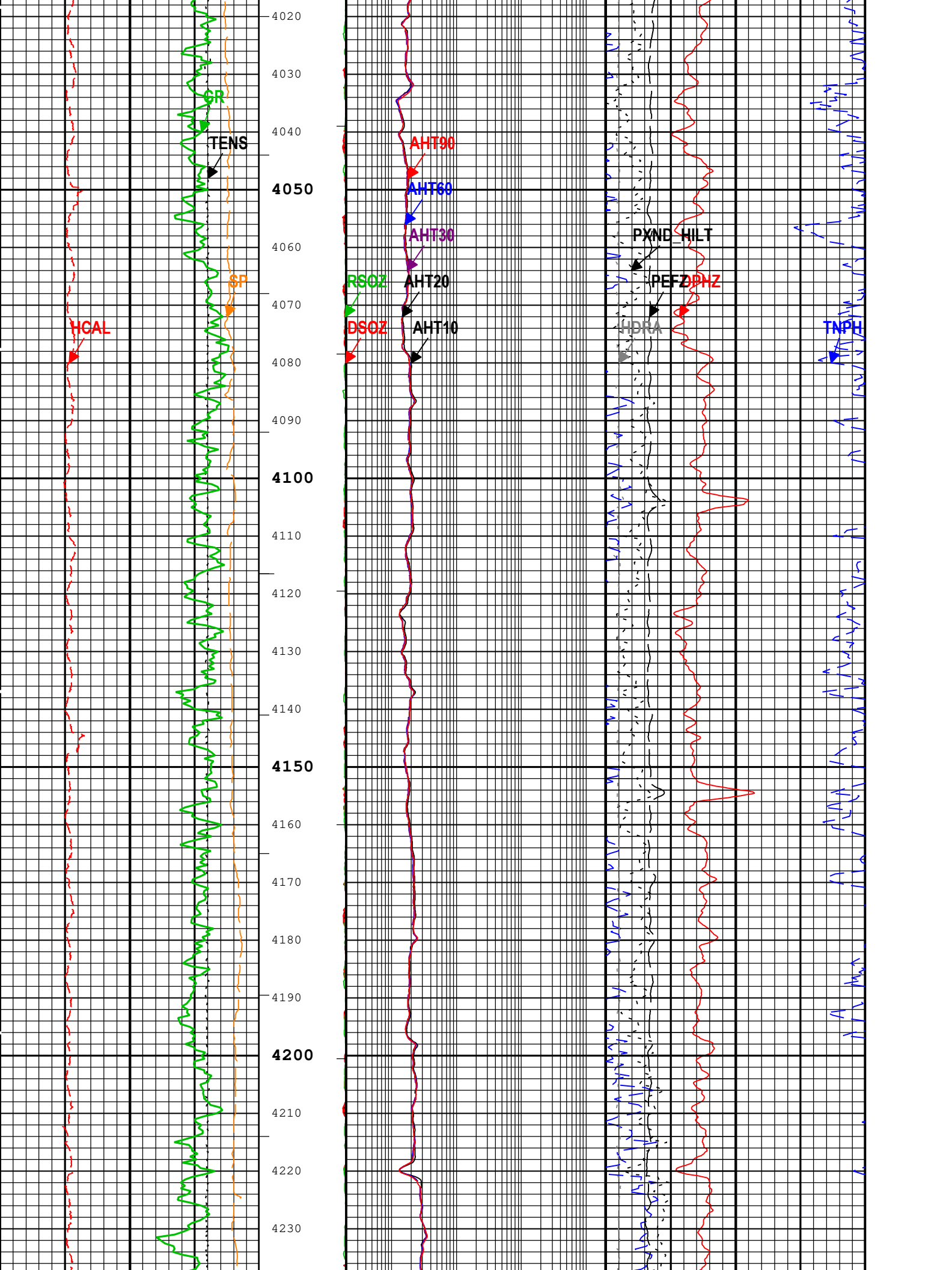
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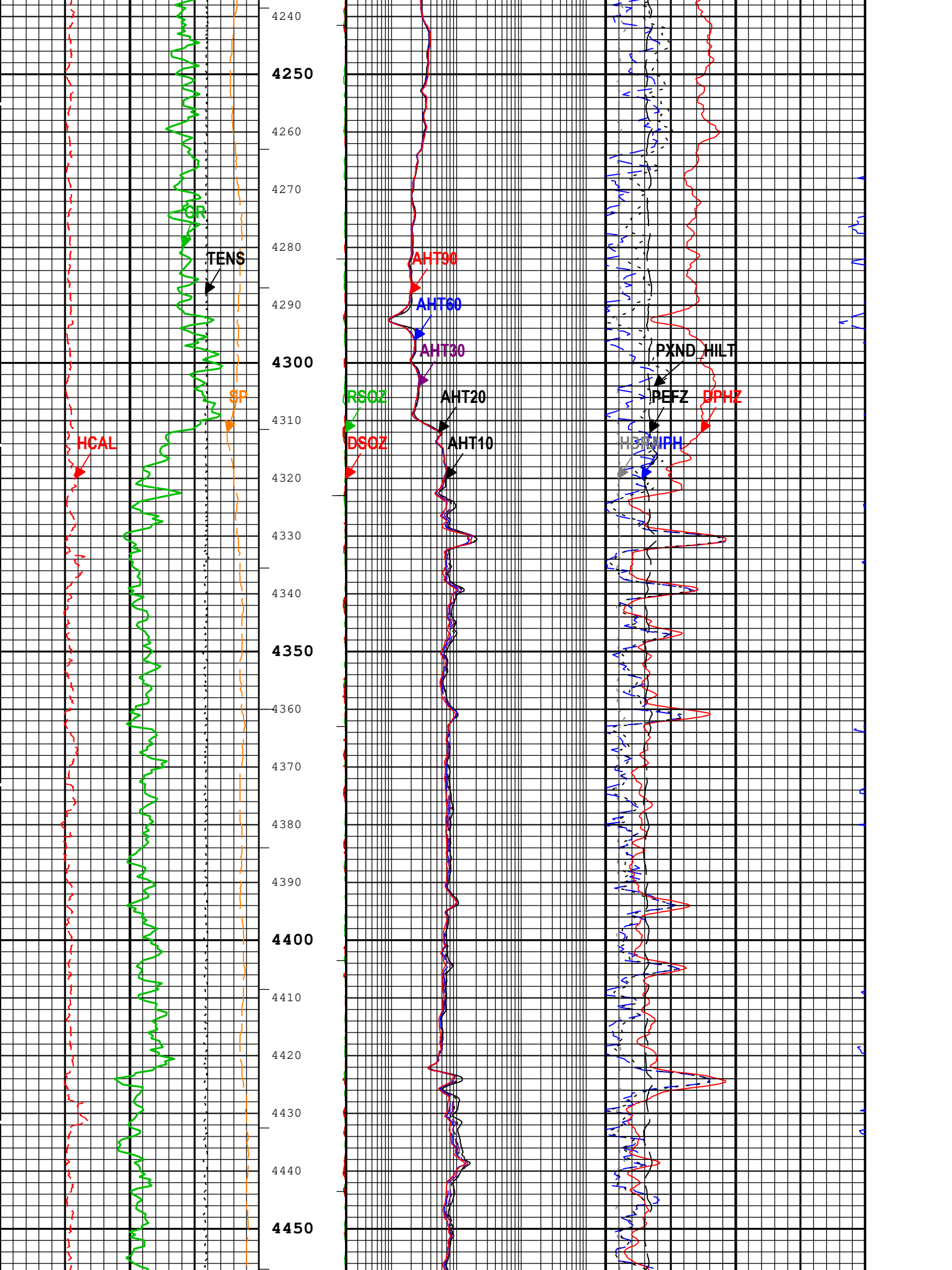
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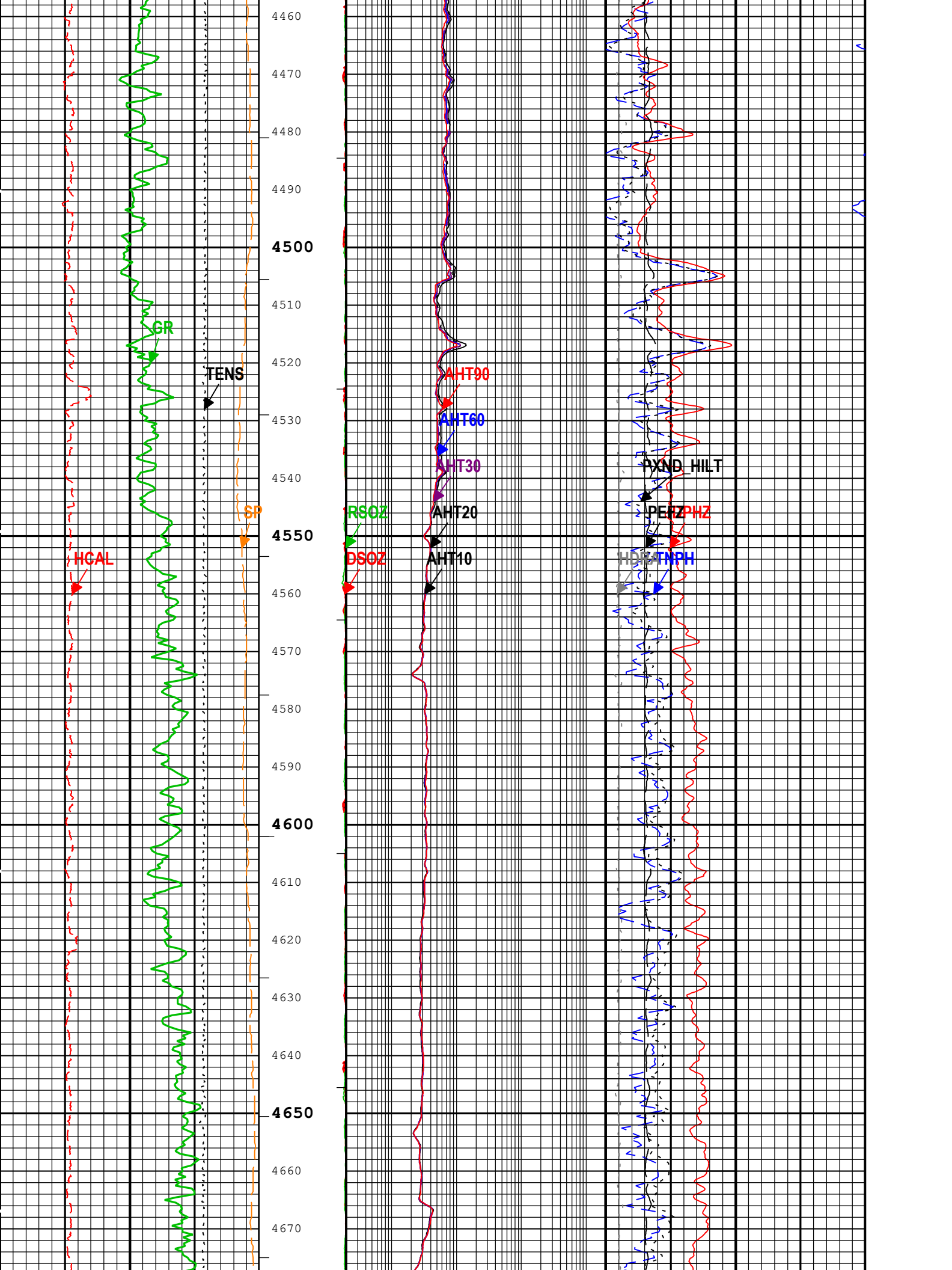
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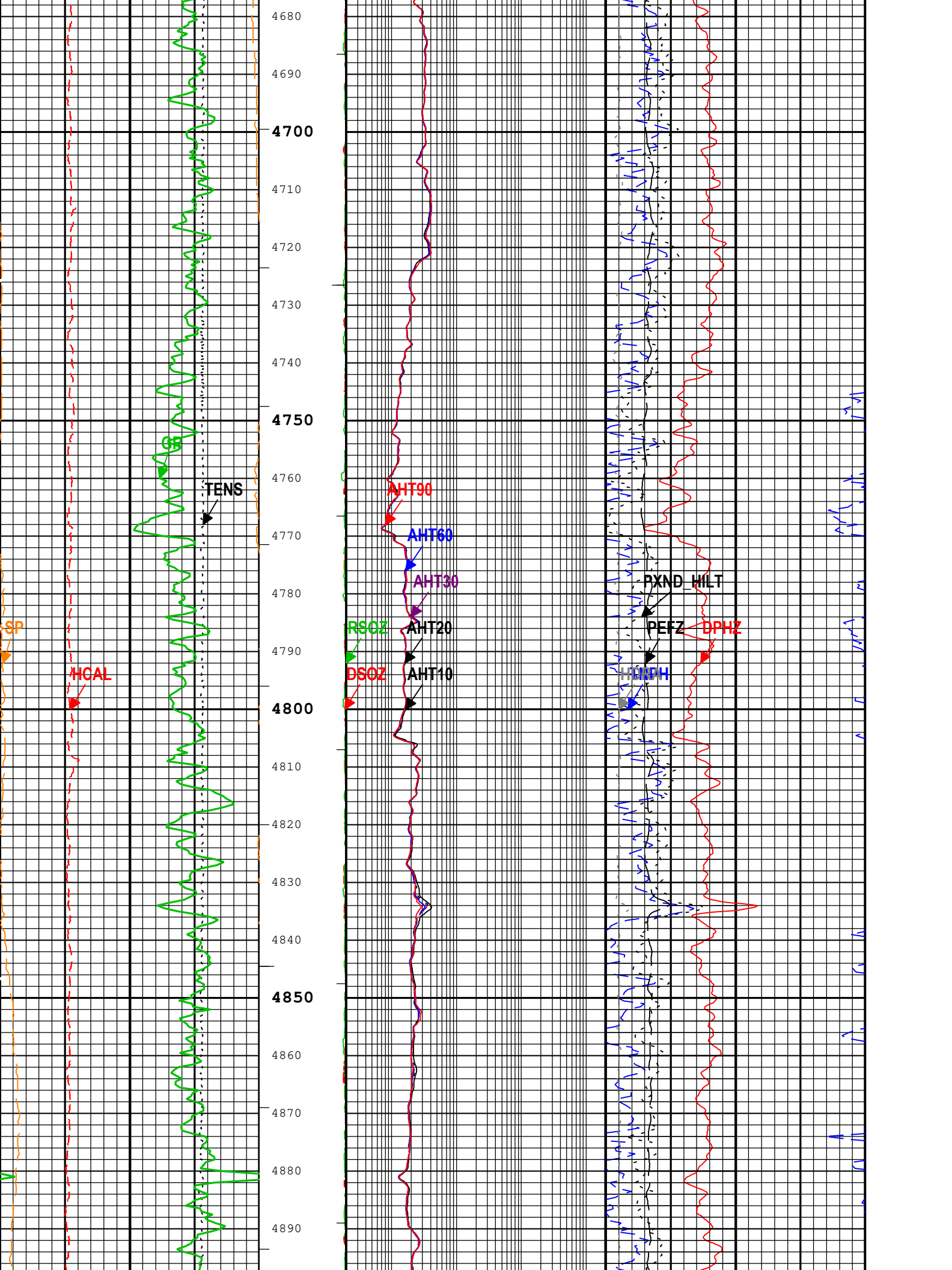
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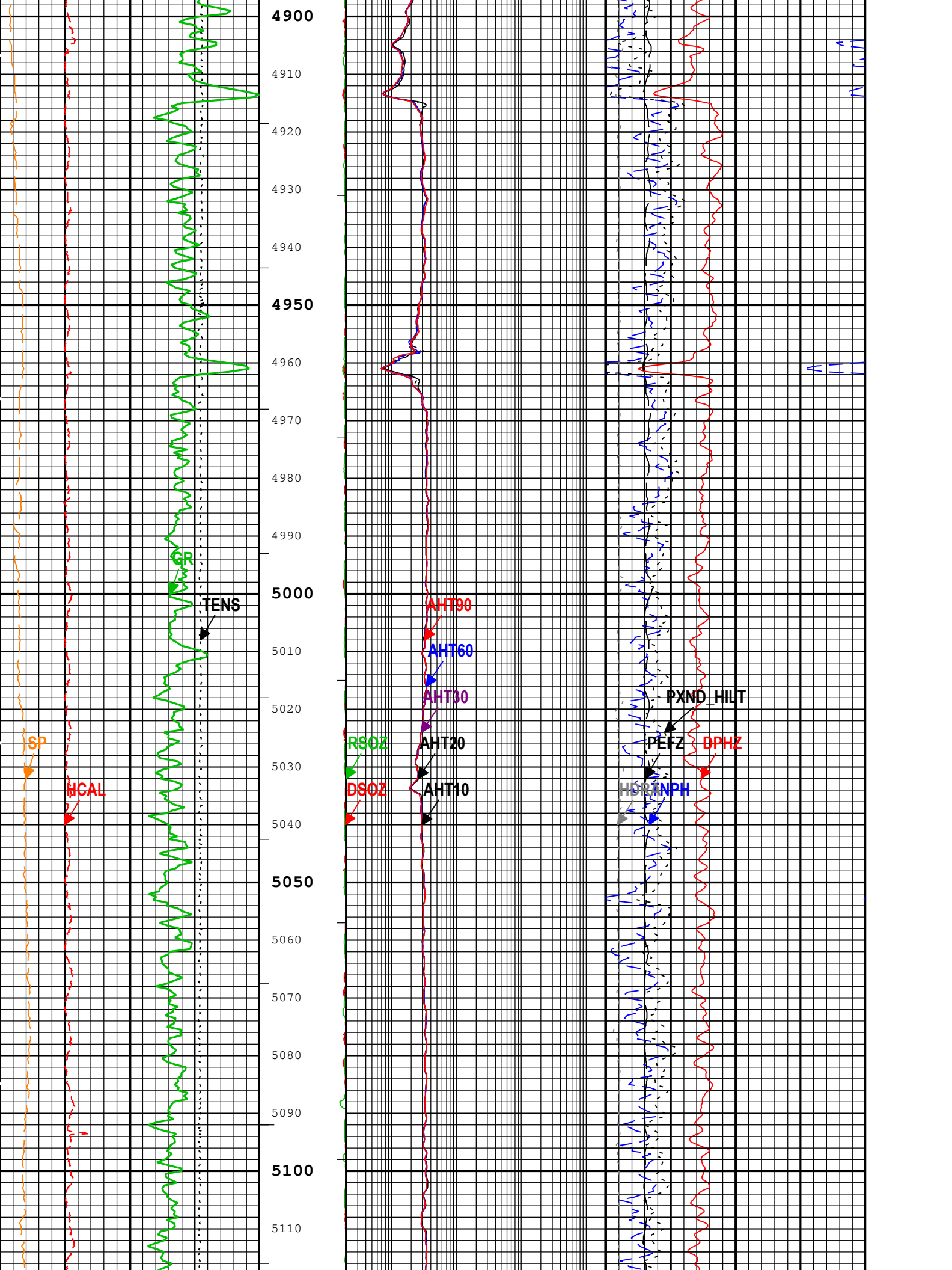
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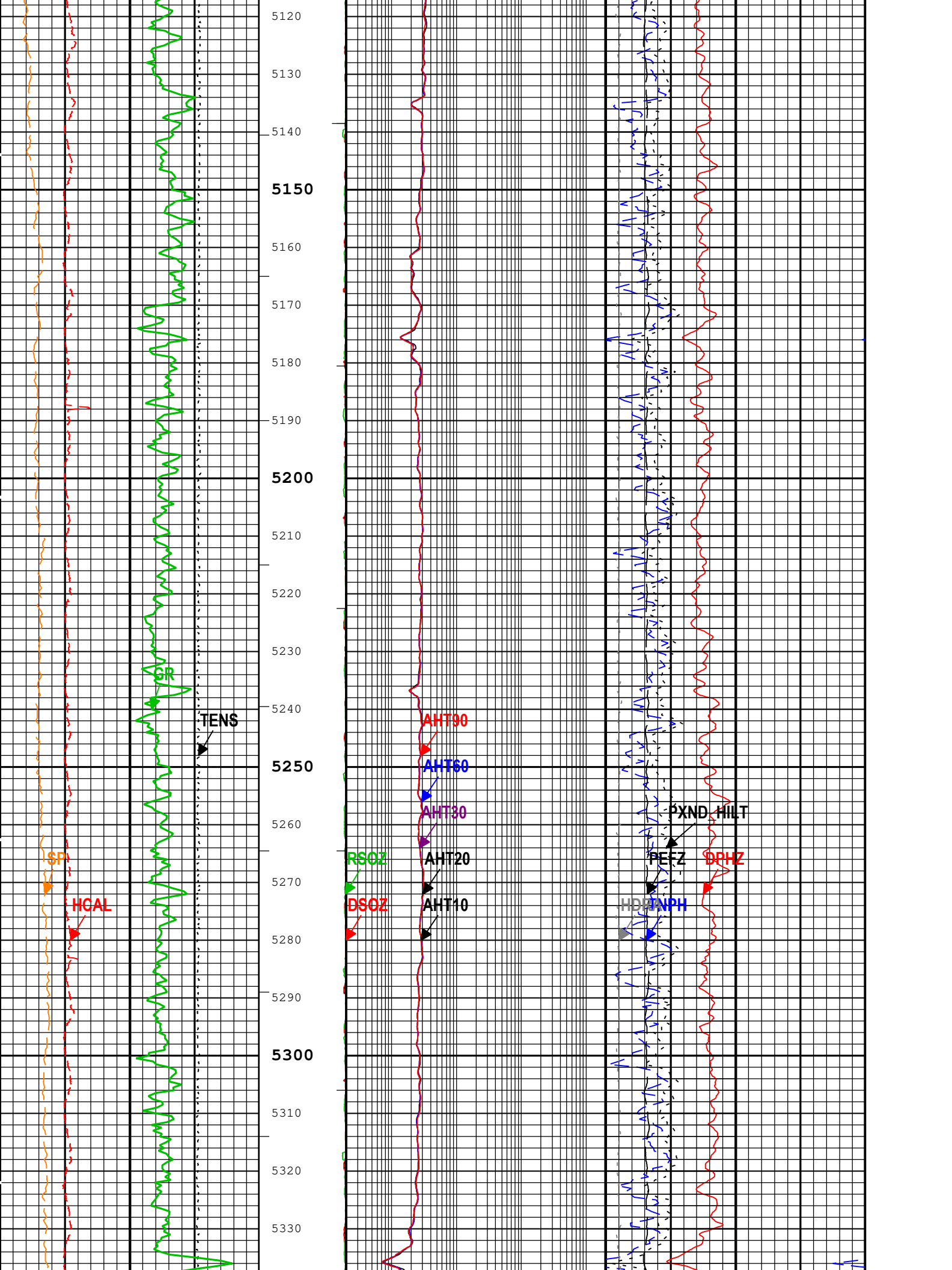
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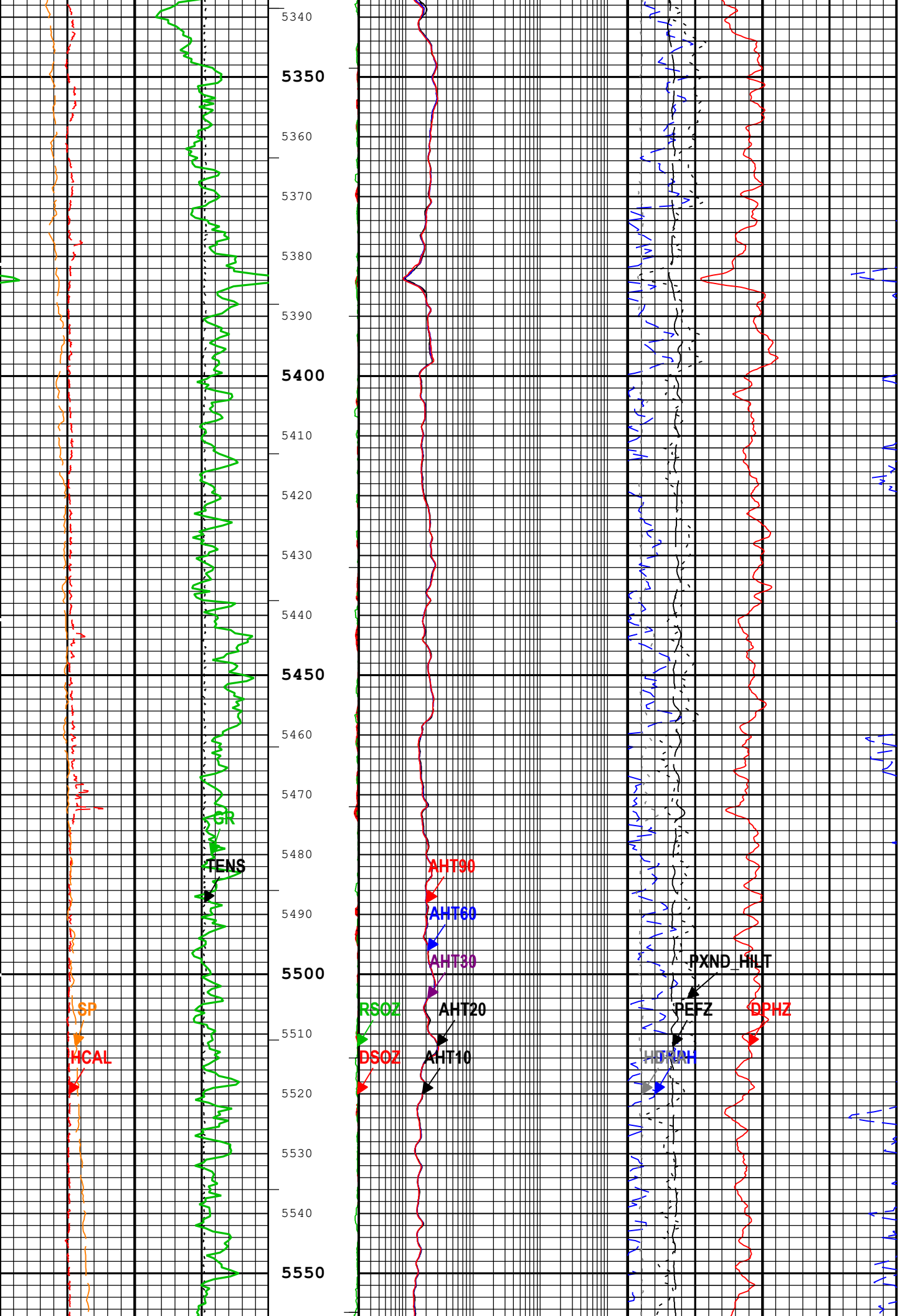
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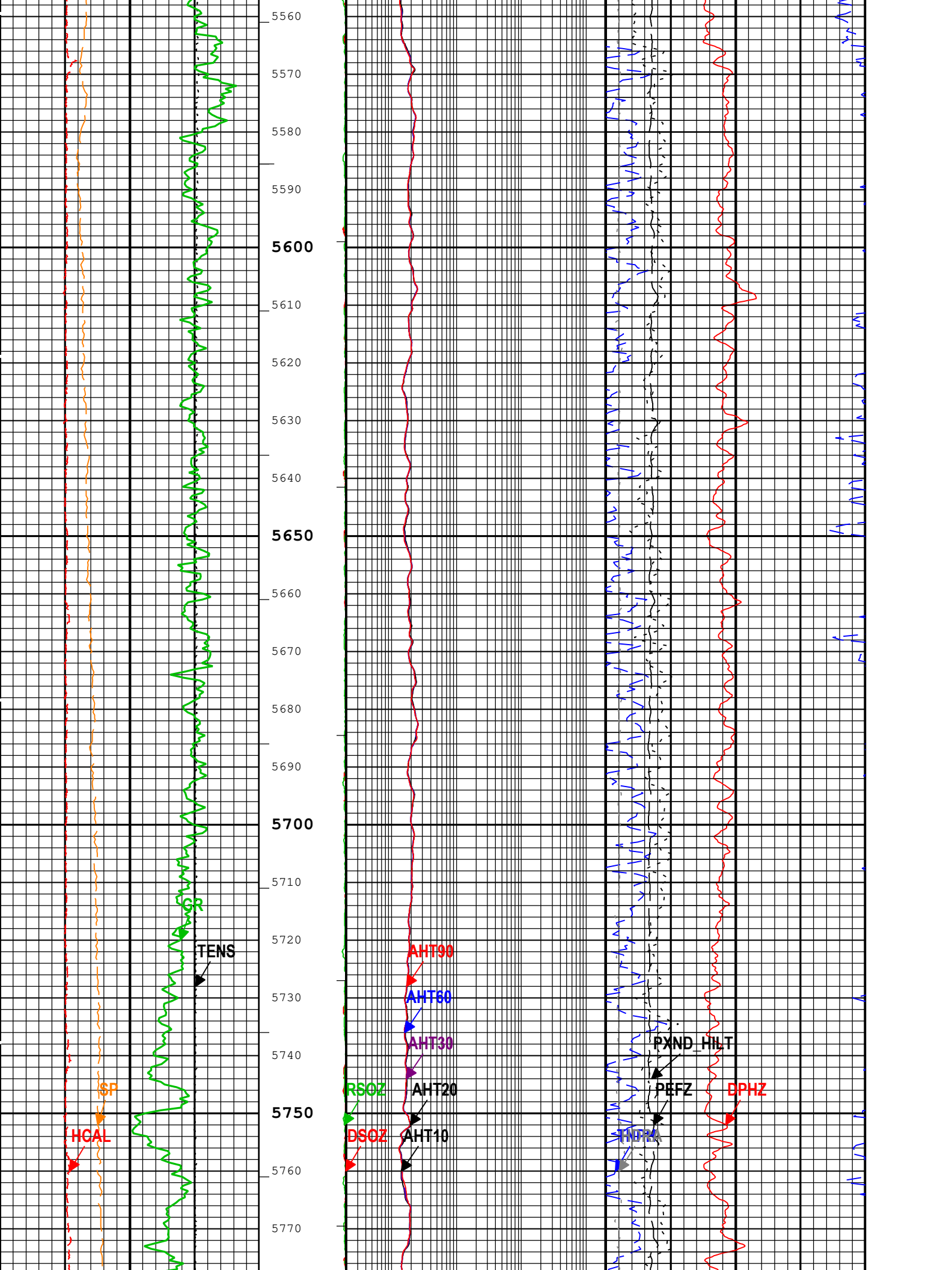
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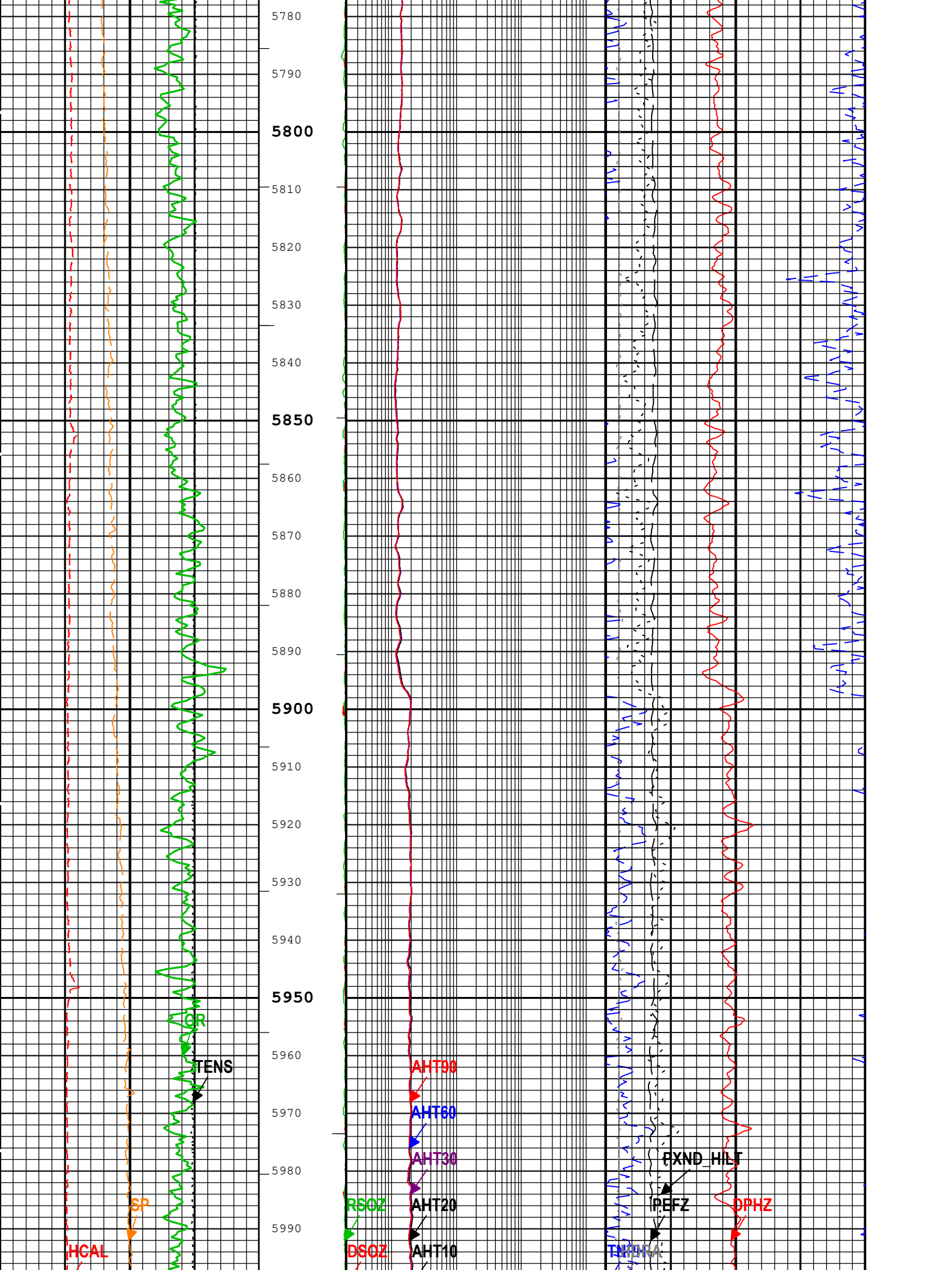
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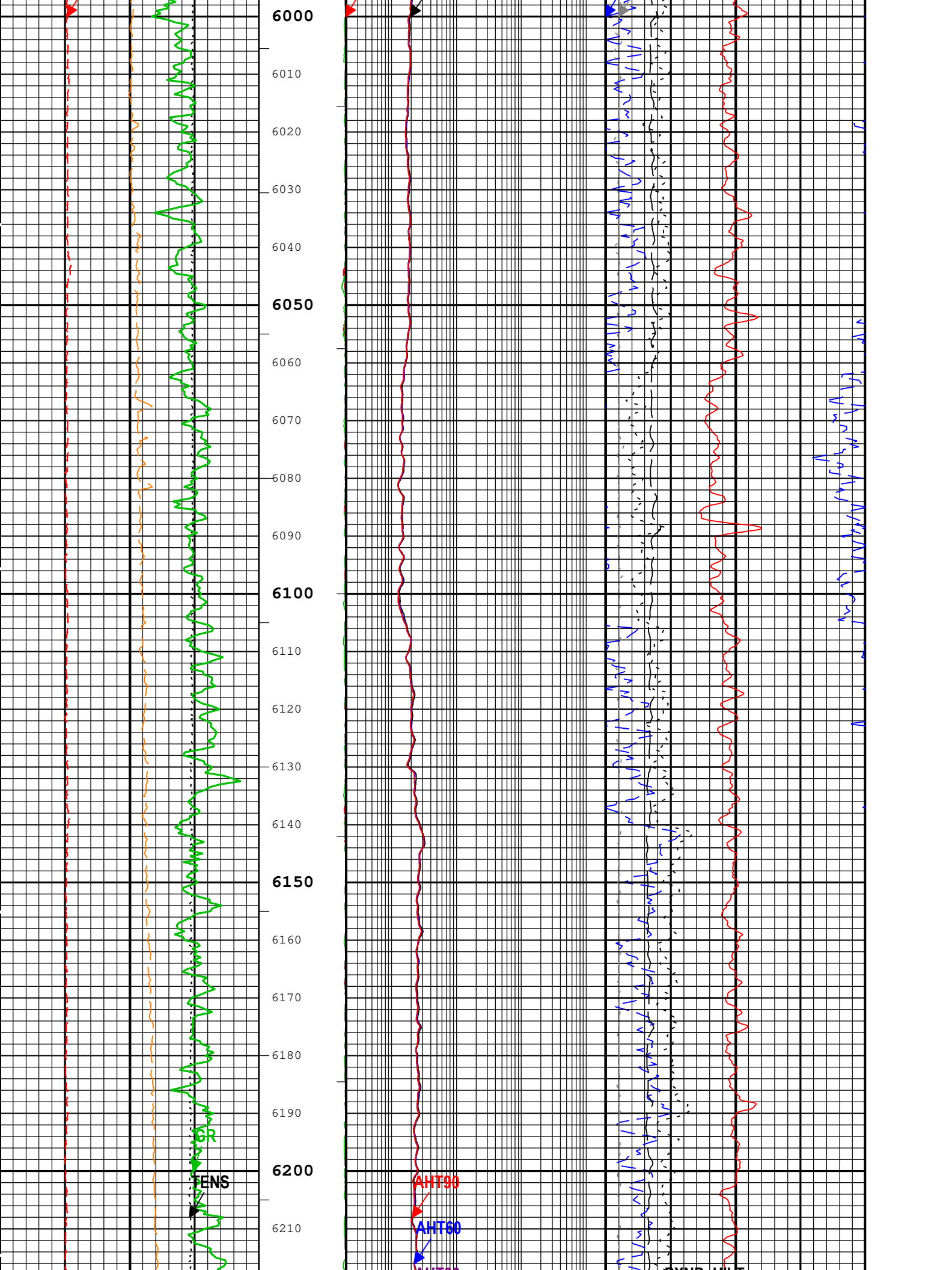
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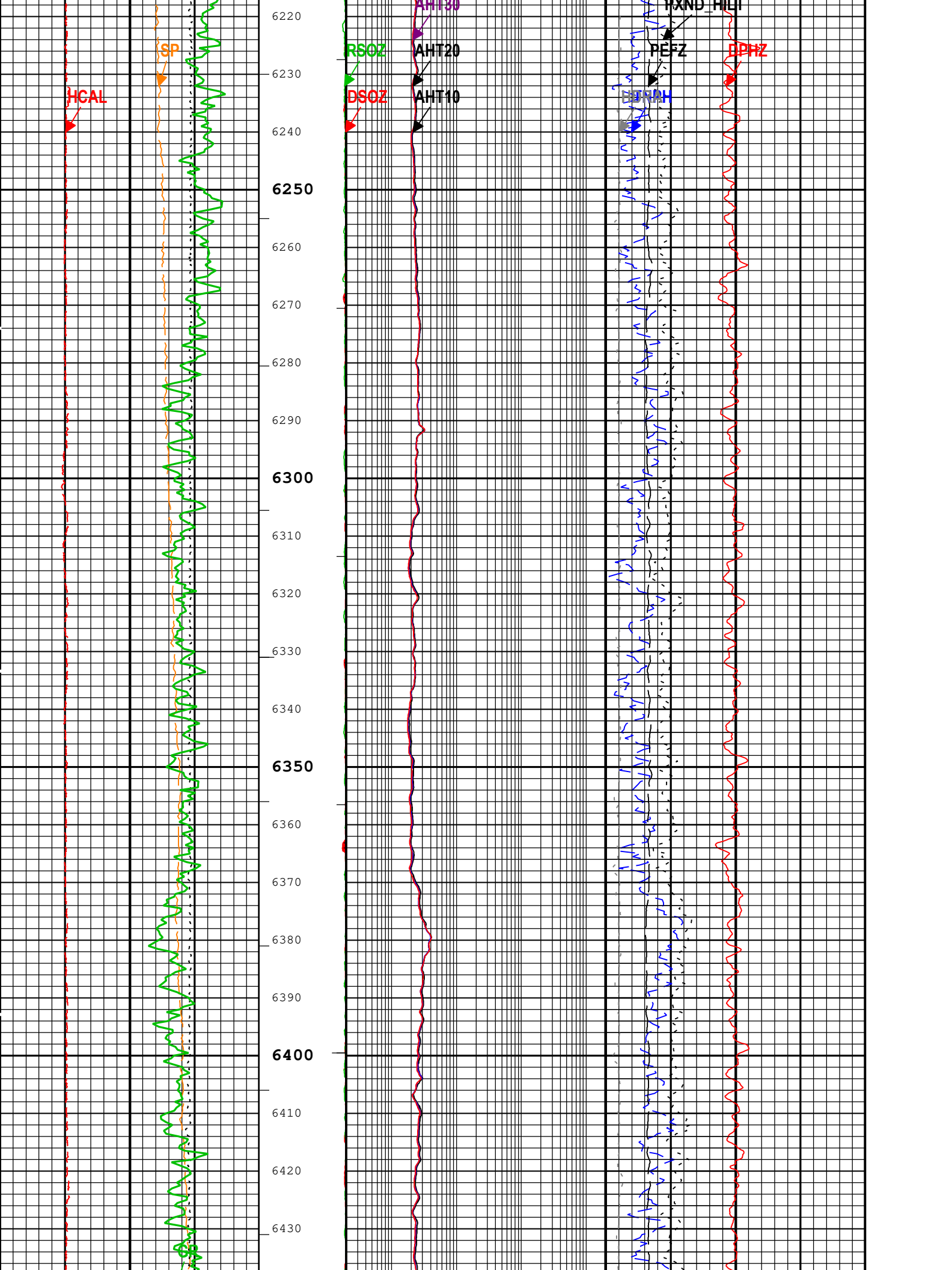
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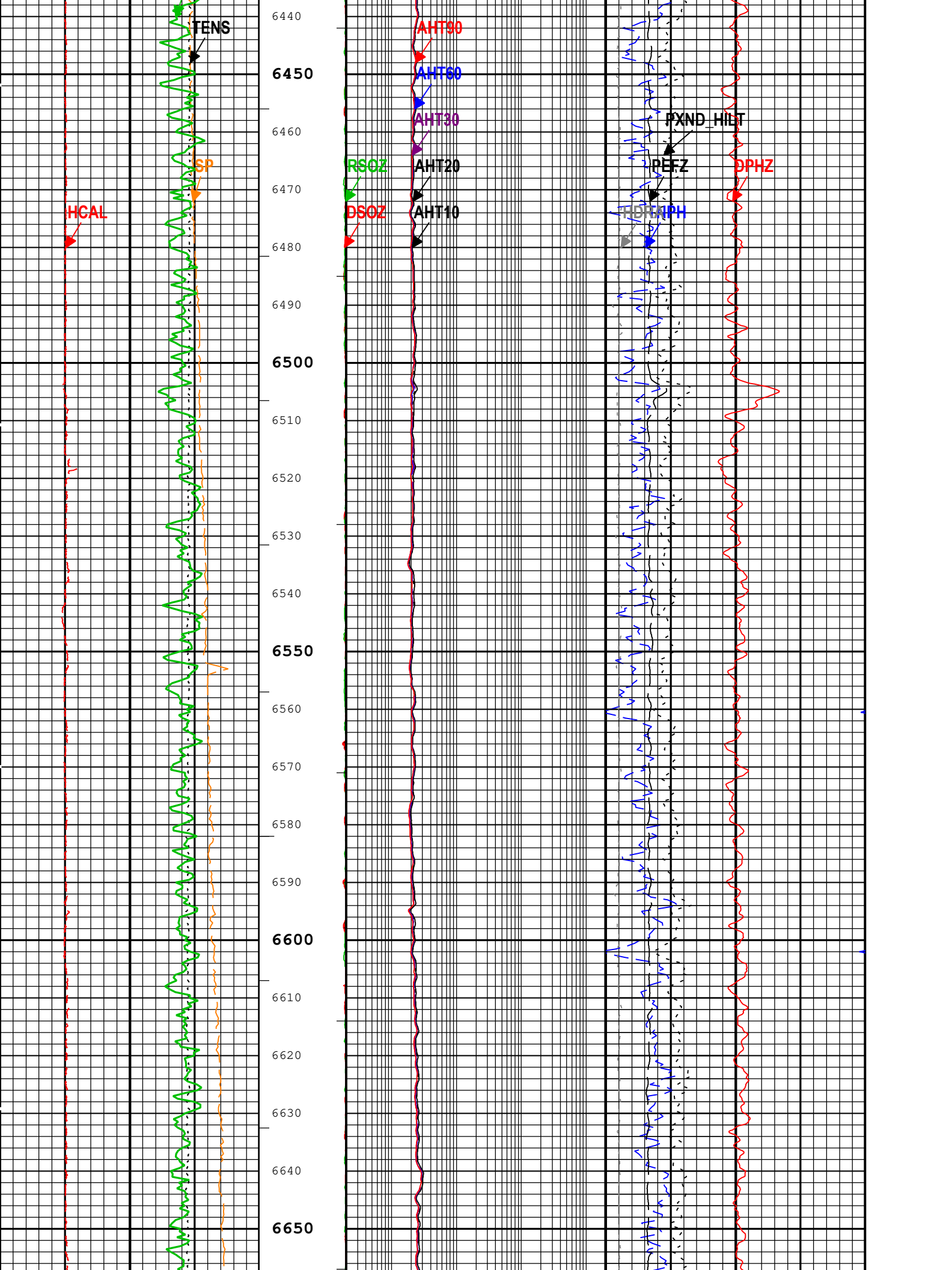
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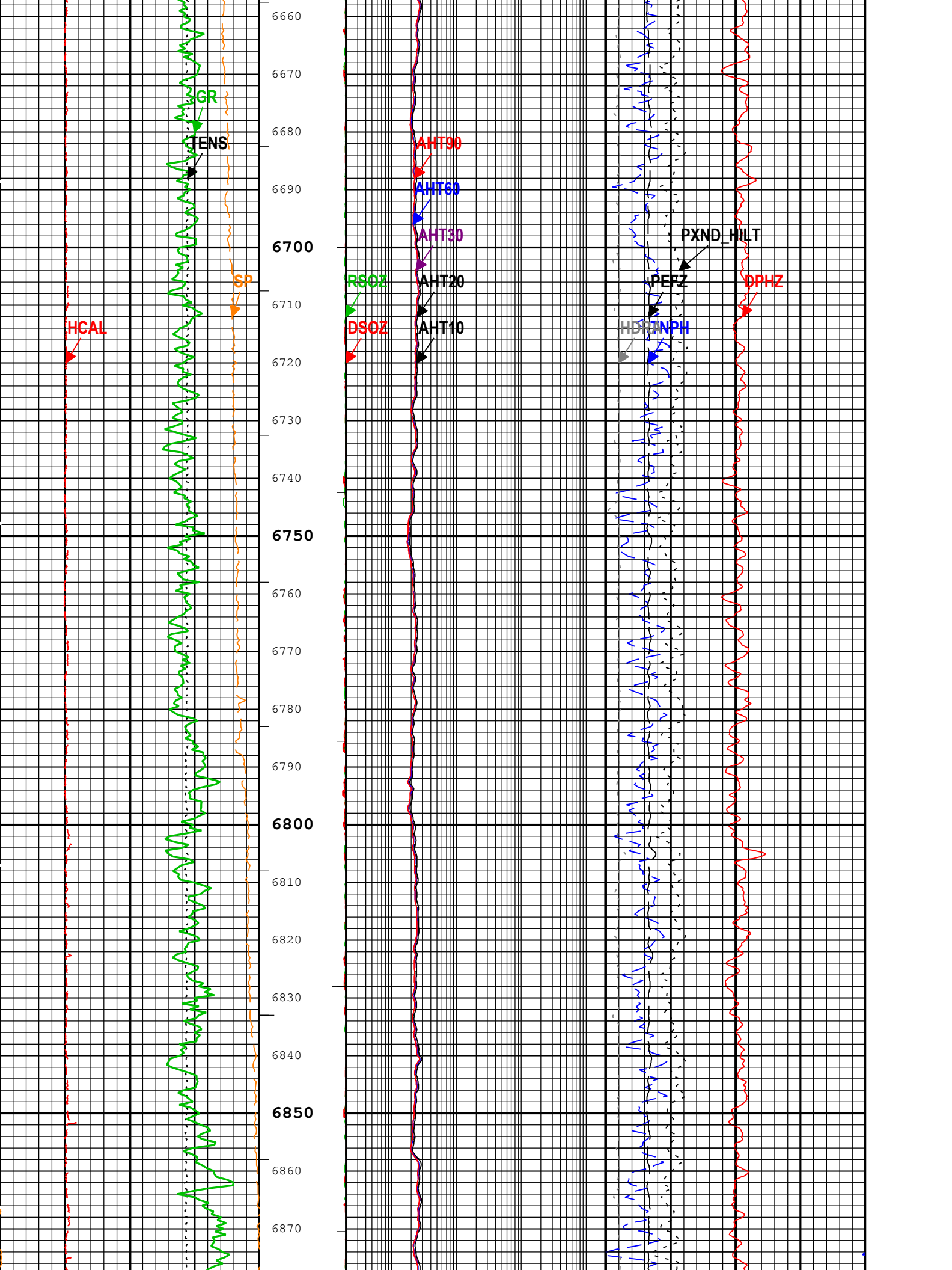
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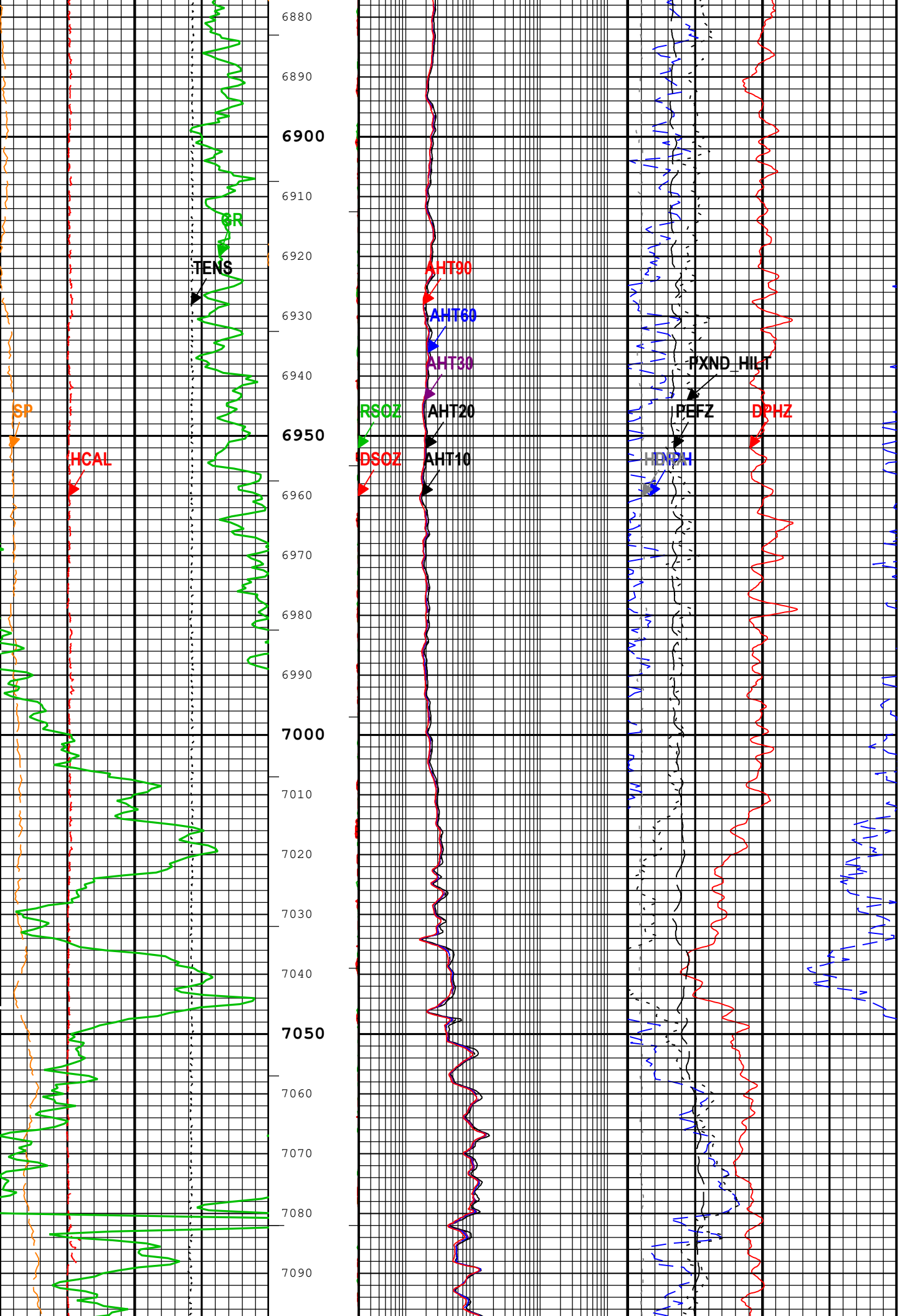
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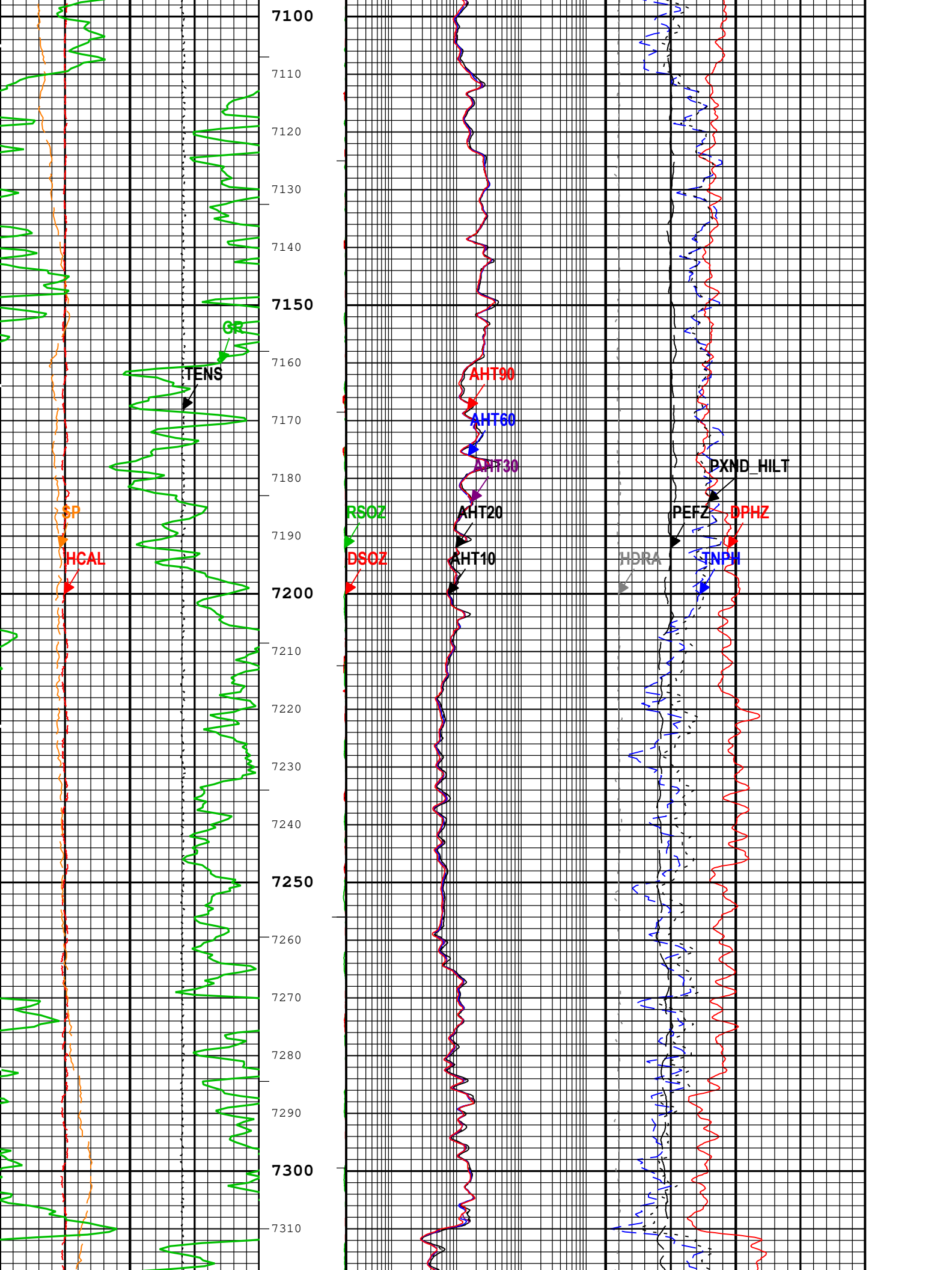
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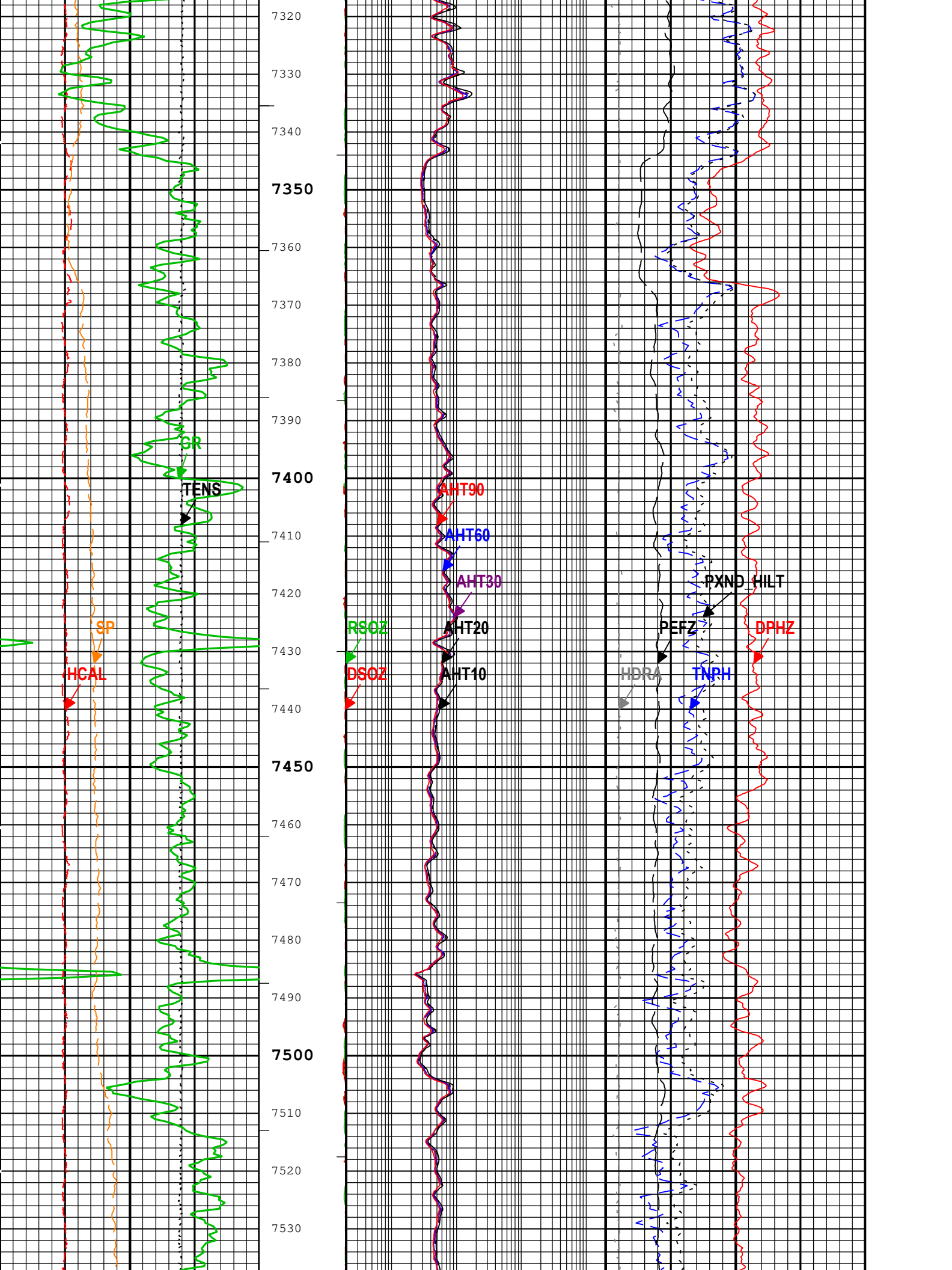
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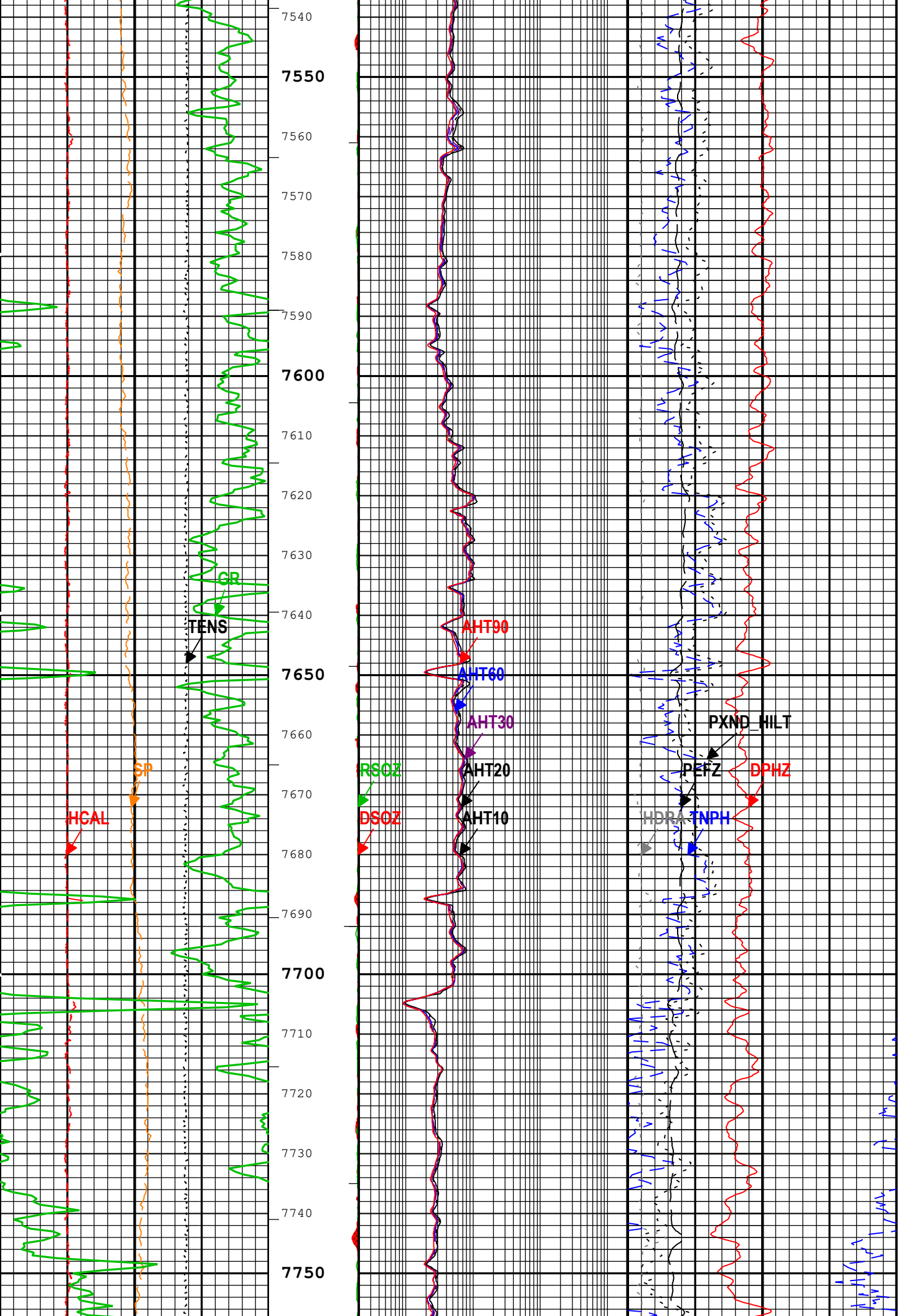
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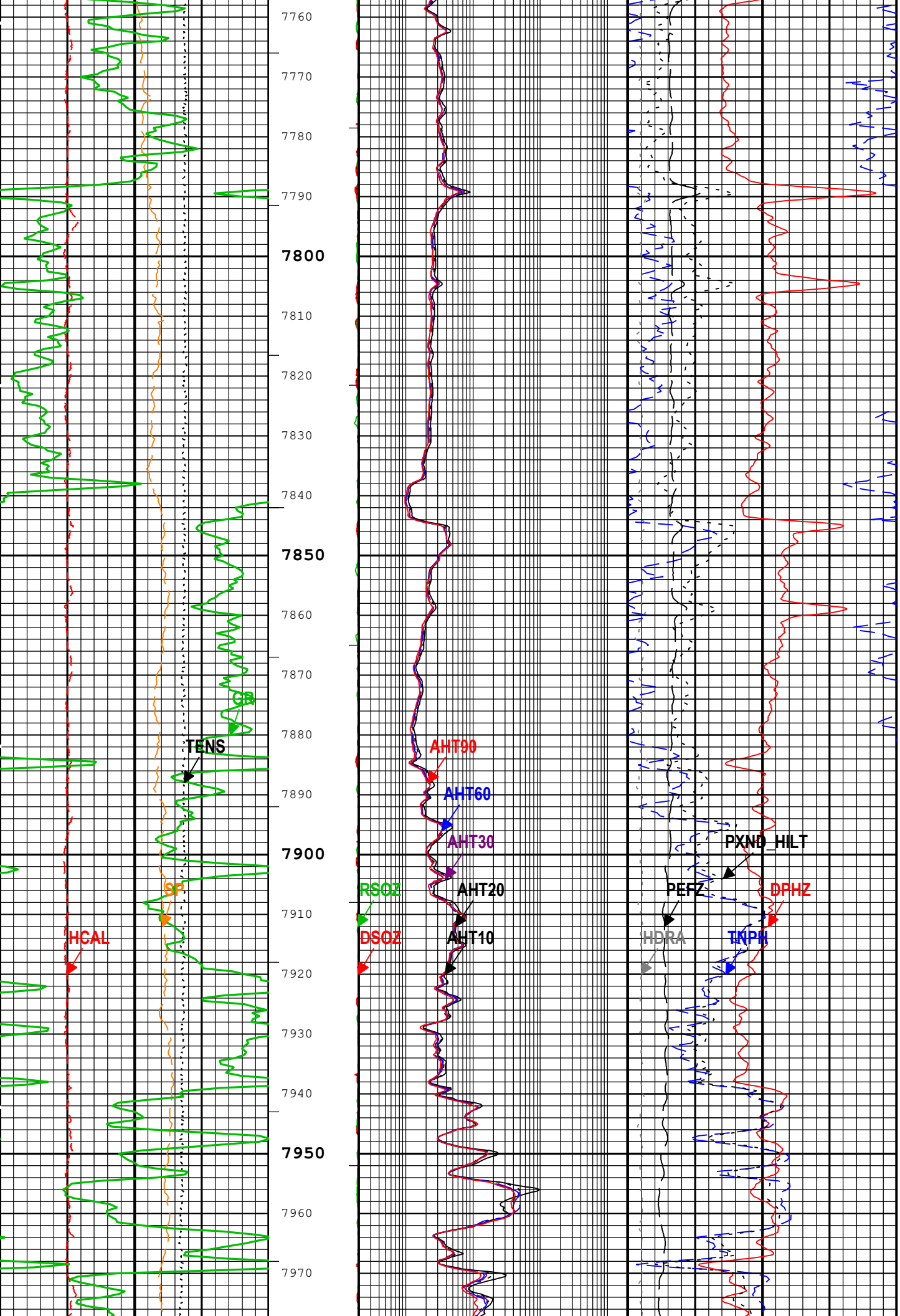
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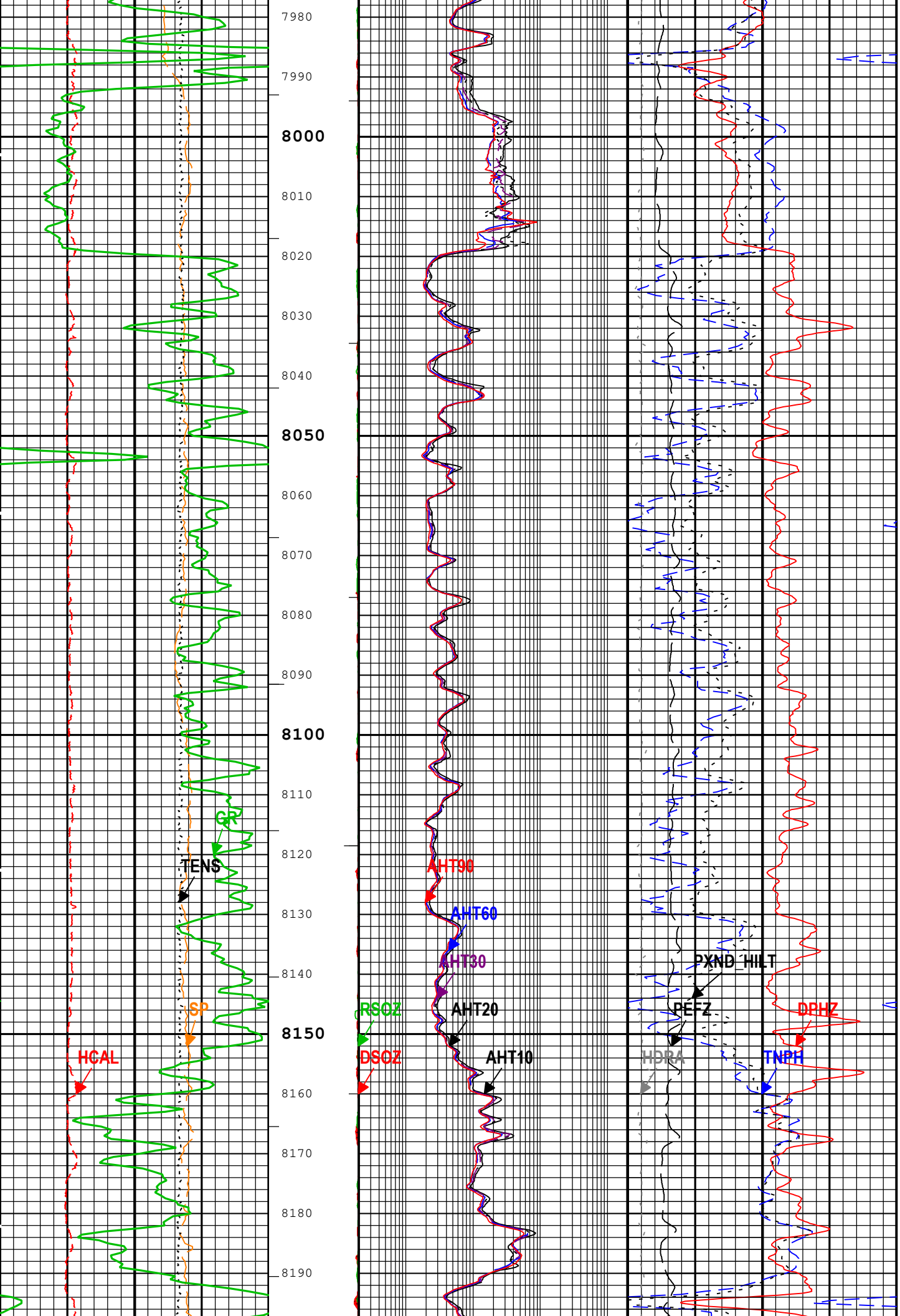
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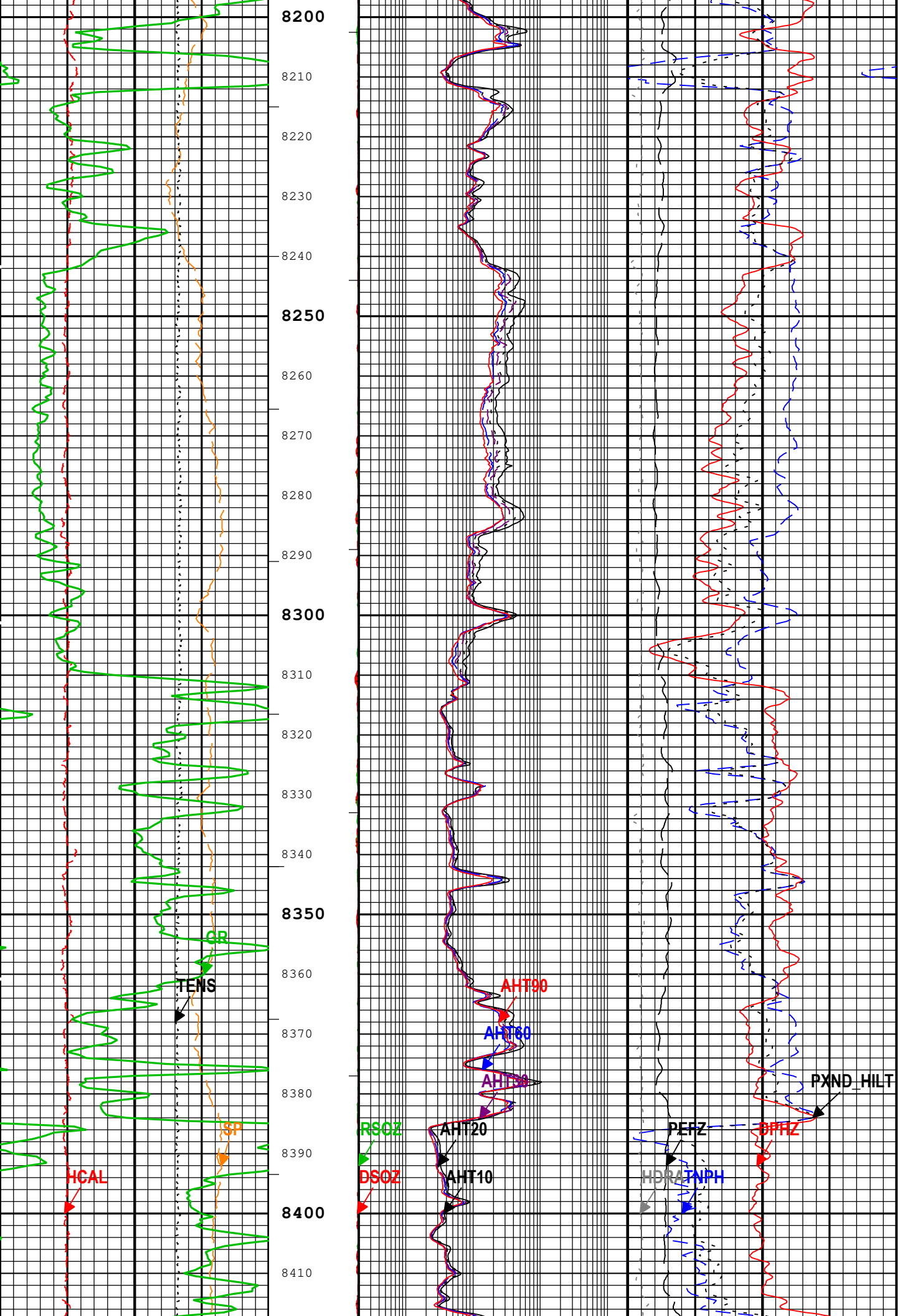
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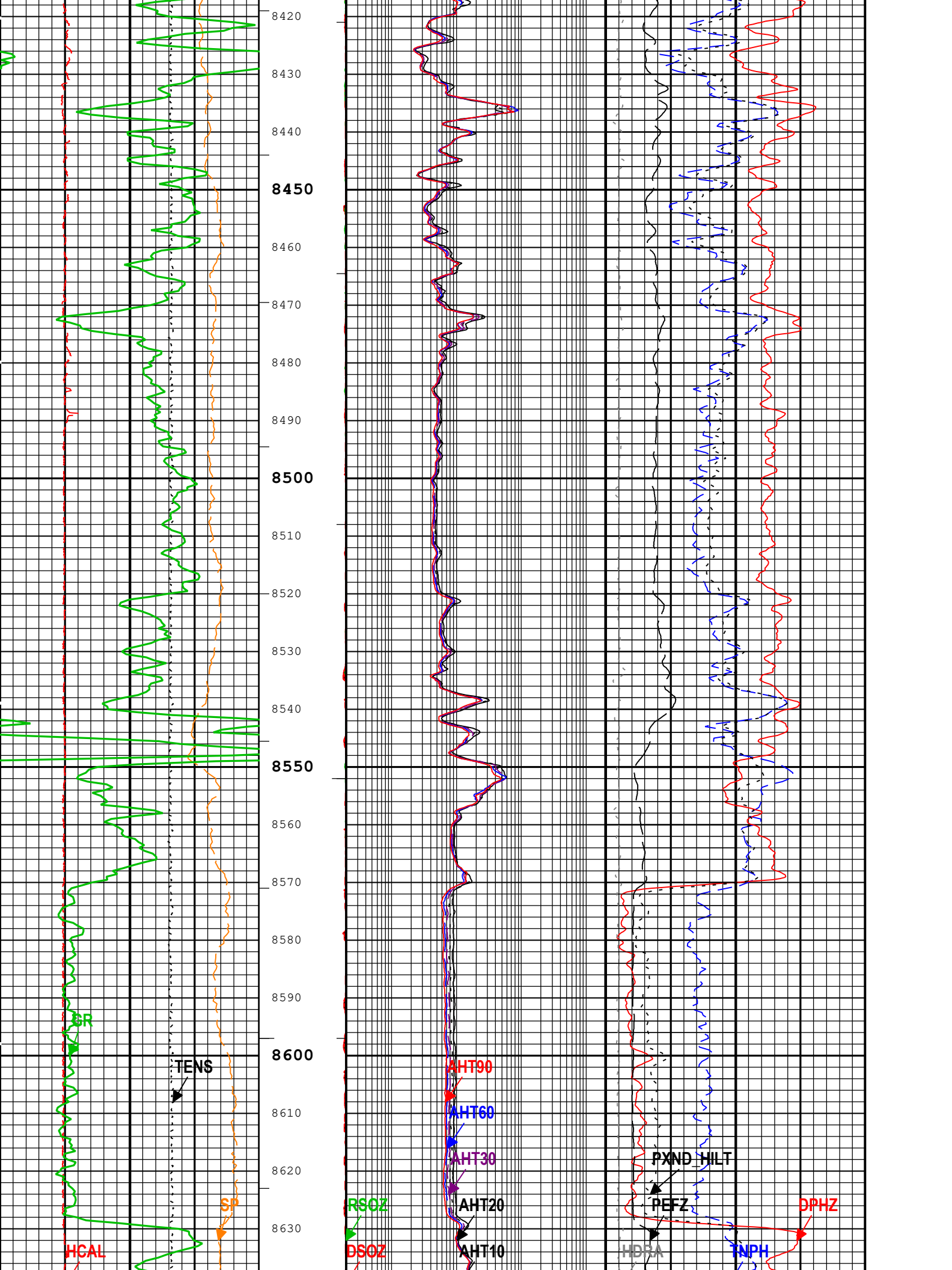
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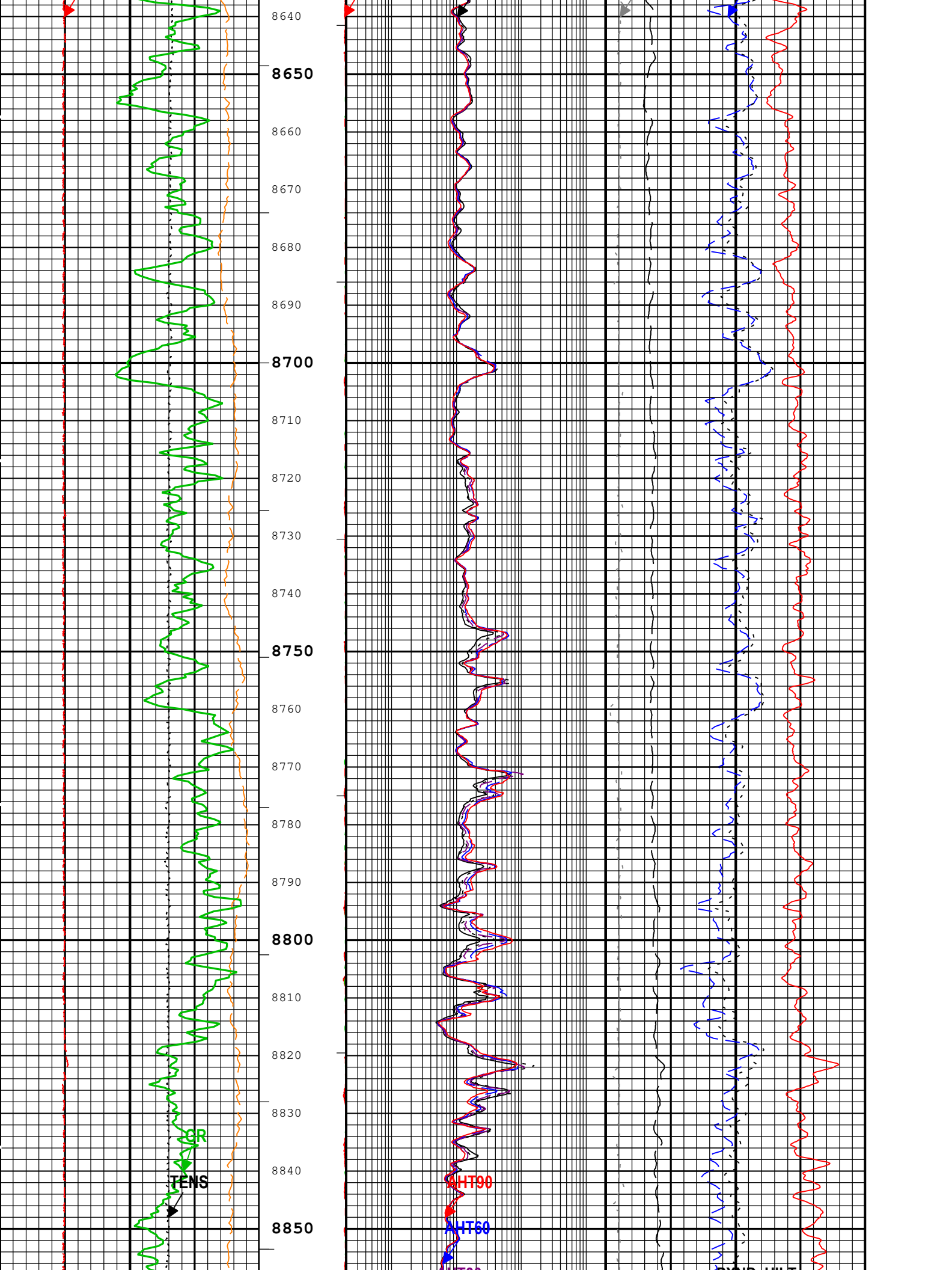
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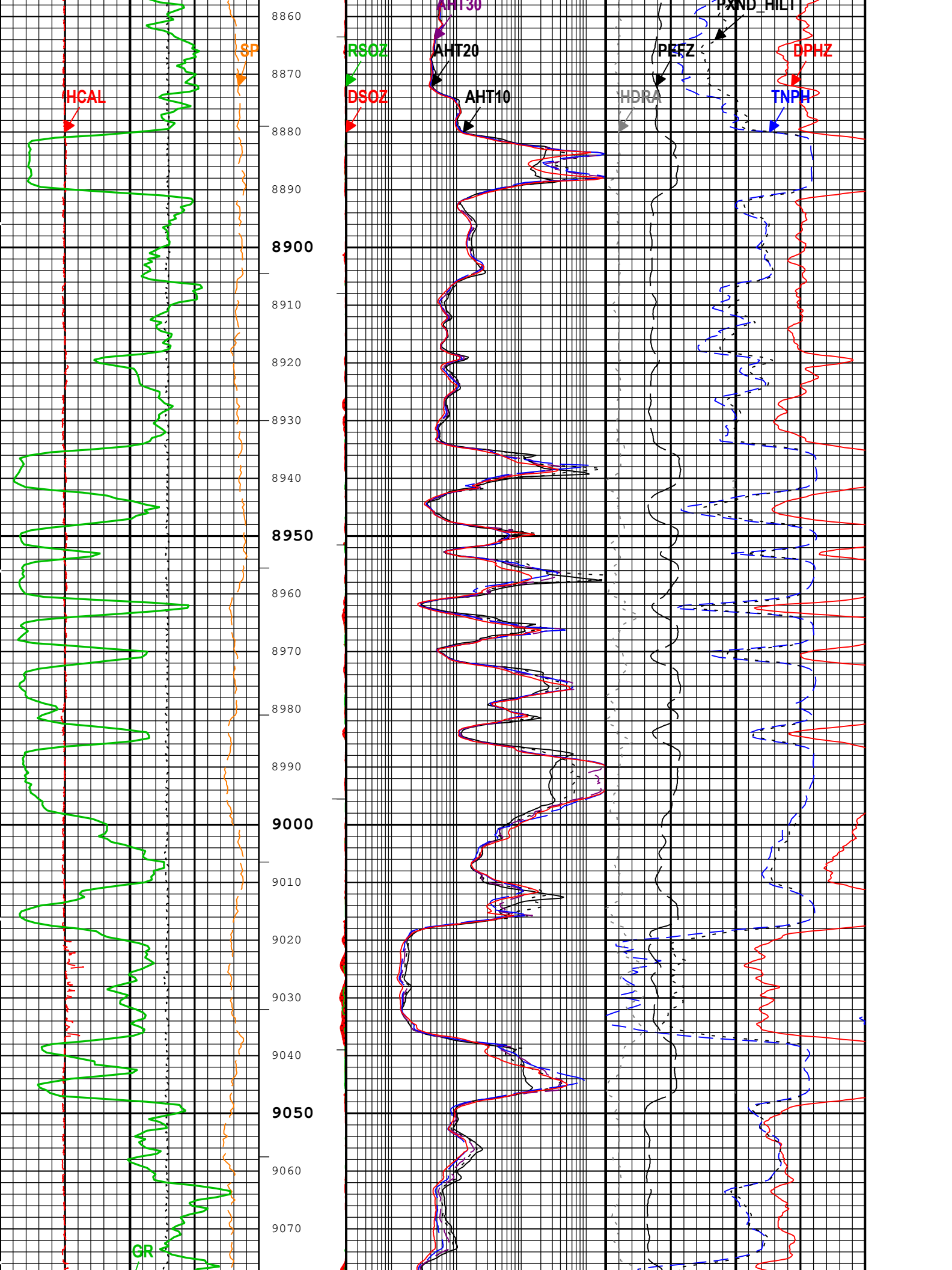
HCAL
SP
GR
RSOZ
DSOZ
AHT30
AHT20
AHT10
PXND_HILT
PEFZ
HDRA
DPHZ
TNPH
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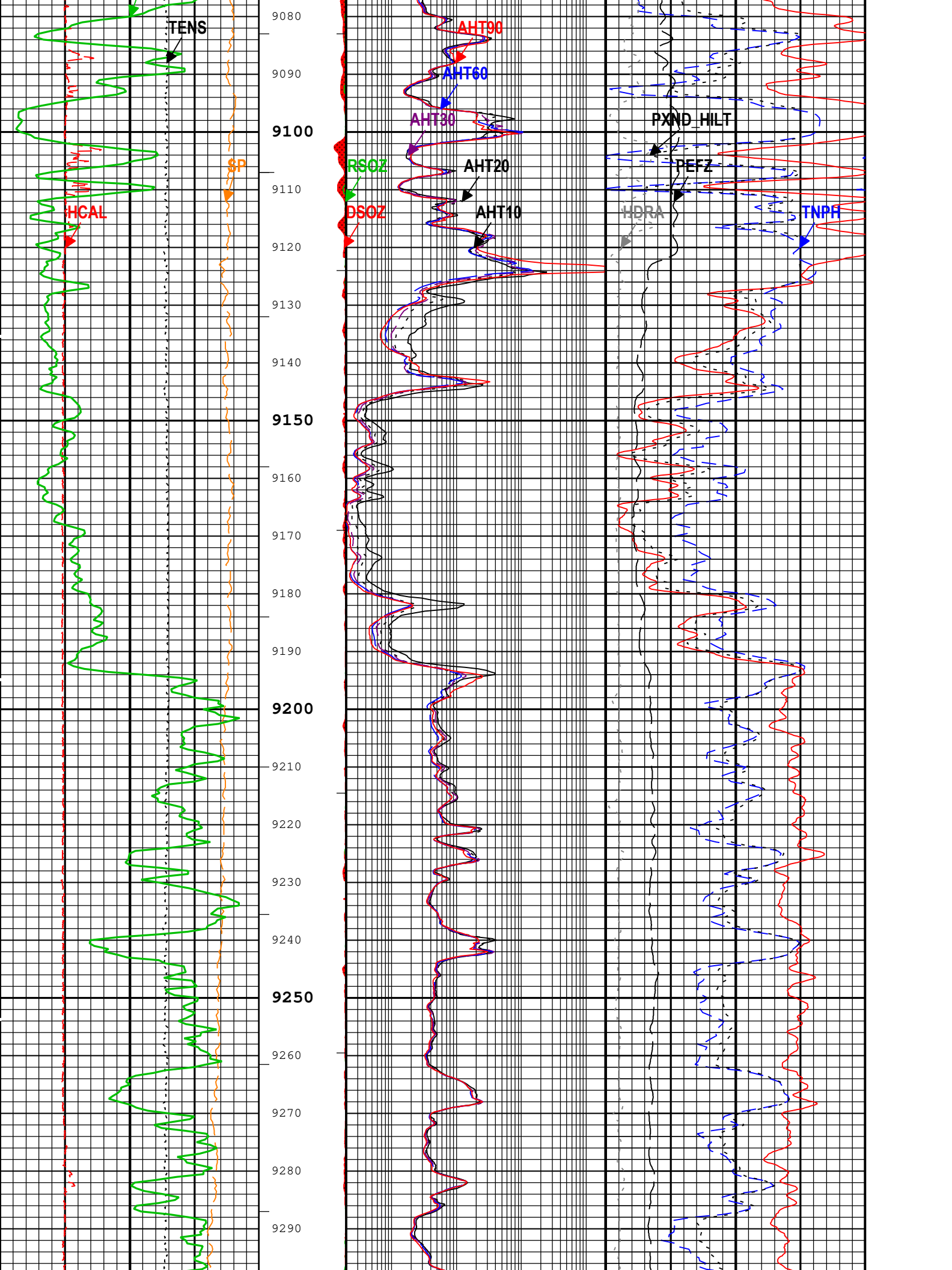
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DSOZ
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AHT20
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PXND_HILT
PEFZ
HDRA
TNPH
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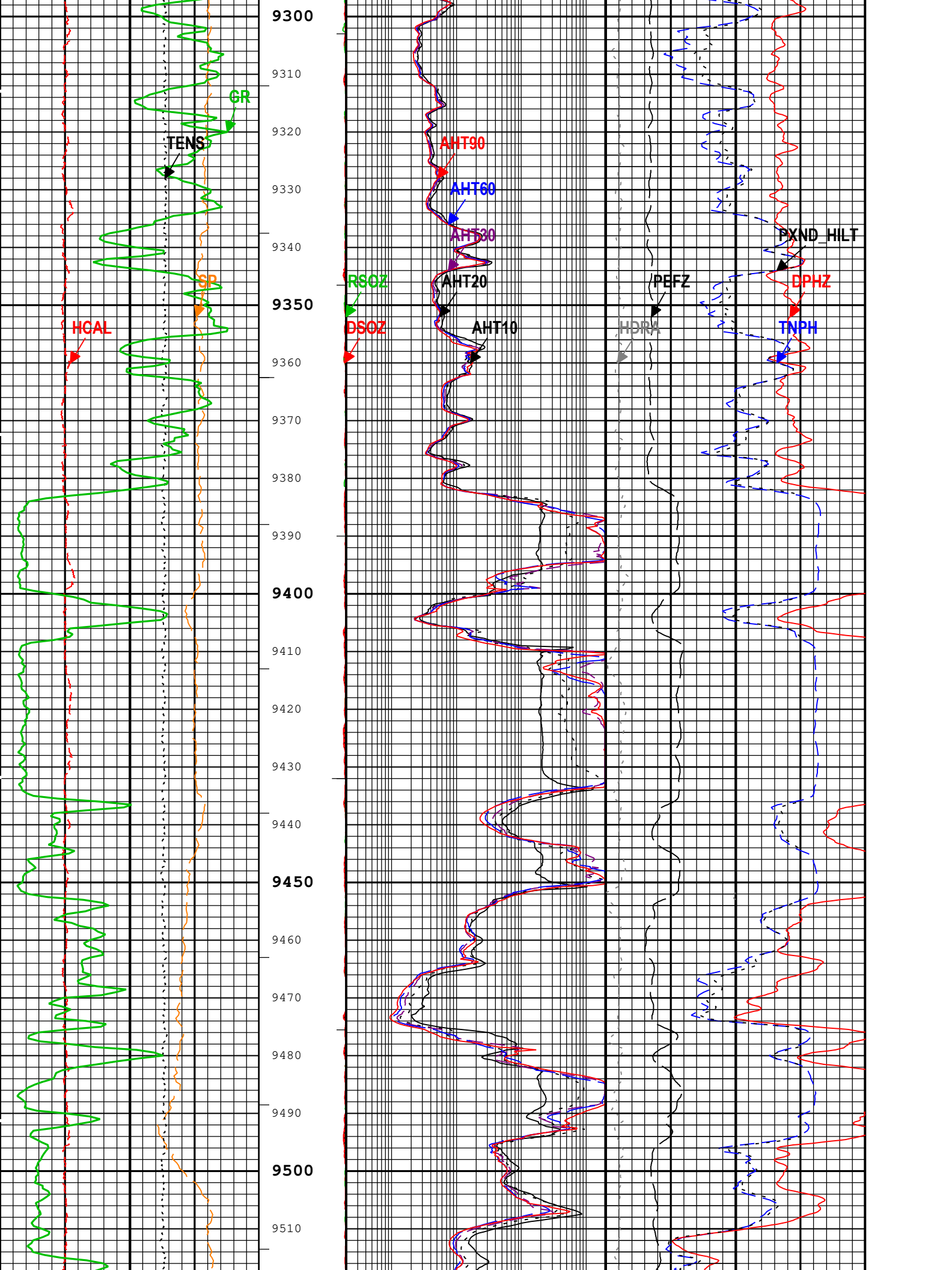
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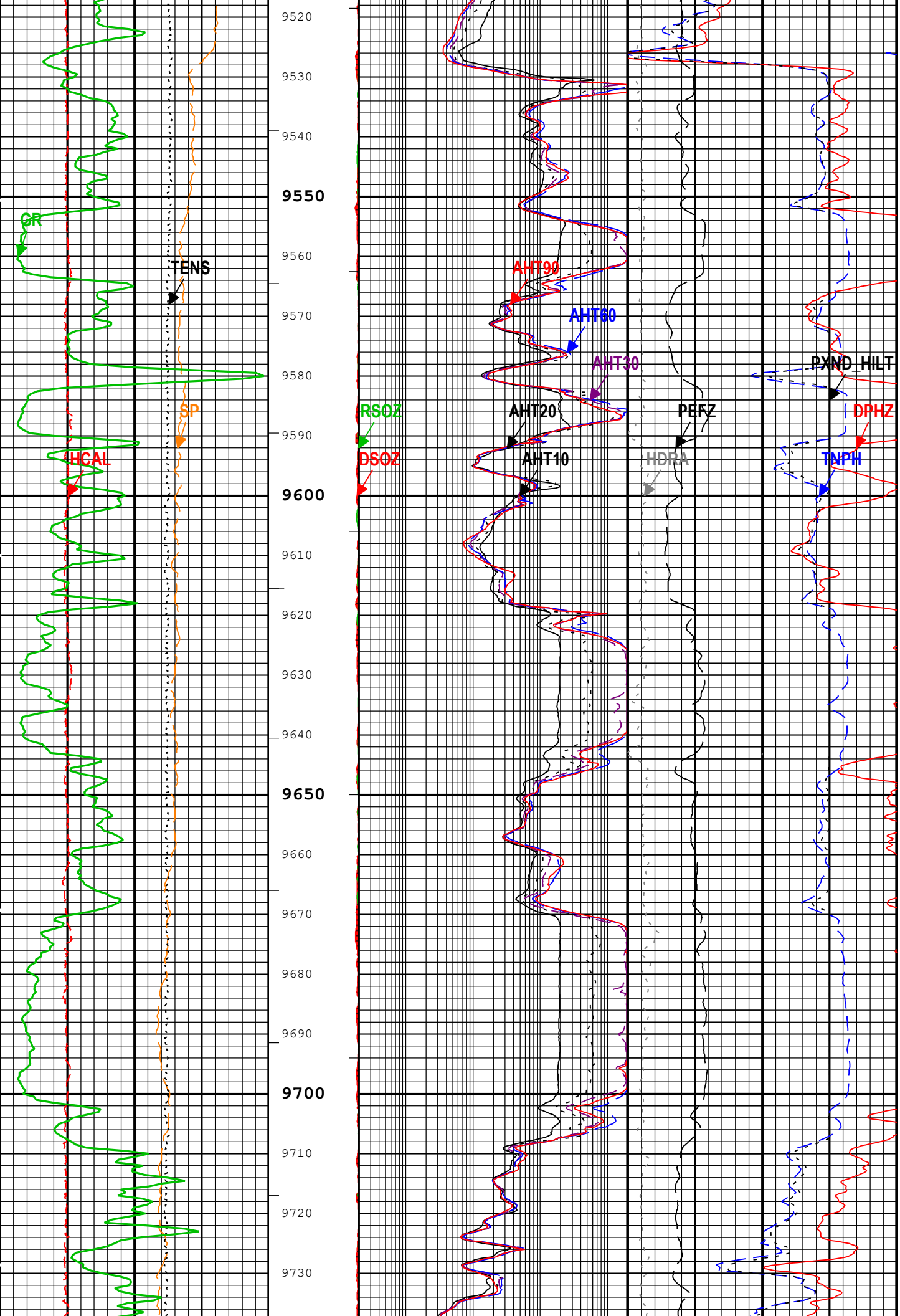
AHT20
AHT10
RSOZ
DSOZ
PEFZ
HDRA
PXND_HILT
DPHZ
TNPH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9690
9700
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9730
SR
TENS
SP
HCAL
RSOZ
DSOZ
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AHT60
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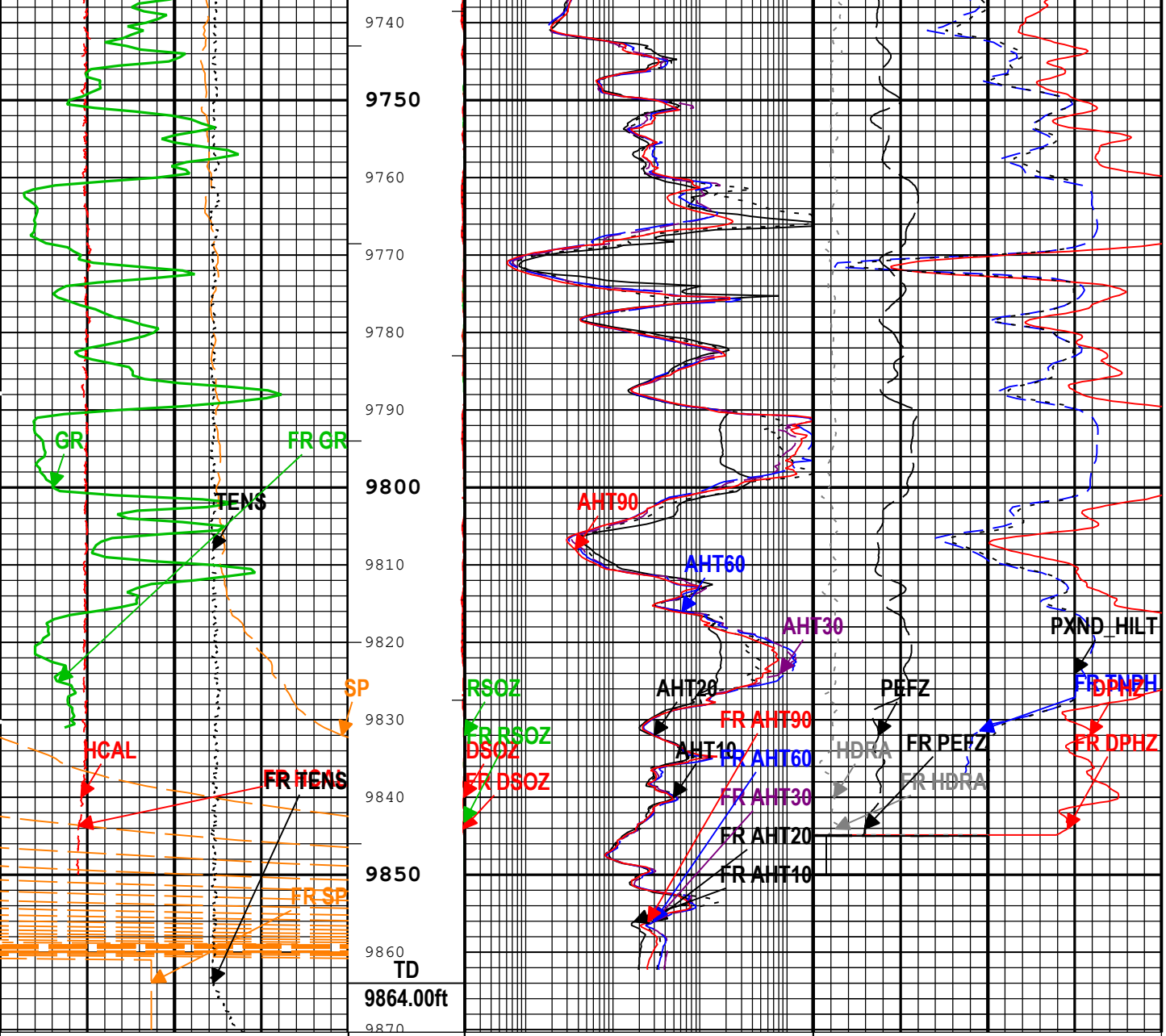
AHT10
PEFZ
HDRA
PXND_HILT
DPHZ
TNPH




| | | |
|---|---|---|
| Caliper (HCAL) HDRS-H<br>6 in 16 | Standard Resolution Density Standoff (DSOZ) HDRS-H<br>2.5 in 0 | Array Induction Two Foot Resistivity A10 (AHT10) AIT-H<br>0.2 ohm.m 2000 |
| Spontaneous Potential (SP) AIT-H<br>-80 mV 20 | | Array Induction Two Foot Resistivity A20 (AHT20) AIT-H<br>0.2 ohm.m 2000 |
| Cable Tension (TENS)<br>10000 lbf 0 | DSOA | Array Induction Two Foot Resistivity A30 (AHT30) AIT-H<br>0.2 ohm.m 2000 |
| Calibrated Gamma Ray (GR) HGNS-H<br>0 gAPI 150 | RSOA | Array Induction Two Foot Resistivity A60 (AHT60) AIT-H<br>0.2 ohm.m 2000 |
| | Resistivity Standoff Standard Resolution (RSOZ) HDRS-H<br>2.5 in 0 | Array Induction Two Foot Resistivity A90 (AHT90) AIT-H<br>0.2 ohm.m 2000 |

| | |
|---|---|
| Thermal Neutron Porosity (Ratio Method) in Selected Lithology (TNPH) HGNS-H<br>0.3 ft3/ft3 -0.1 | |
| Standard Resolution Density Porosity (DPHZ) HDRS-H<br>0.3 ft3/ft3 -0.1 | |
| Crossplot Porosity for Neutron-Density (PXND_HILT)<br>0.3 ft3/ft3 -0.1 | |
| Density Standoff Correction (HDRA) HDRS-H<br>-0.05 g/cm3 0.45 | |
| Standard Resolution Formation Photoelectric Factor (PEFZ) HDRS-H<br>0 10 | |

TIME_1900 - Time Marked every 60.00 (s)

- IHV - Integrated Hole Volume every 10.00 (ft3)
  - ICV - Integrated Cement Volume every 100.00 (ft3)
  - ICV - Integrated Cement Volume every 10.00 (ft3)
- IHV - Integrated Hole Volume every 100.00 (ft3)

Description: Triple Combo standard resolution template for Platform Express  Format: Log ( TCOM 5in )  Index Scale: 5 in per 100 ft  Index Unit: ft  Index Type: Measured Depth  Creation Date: 24-Feb-2023 02:44:22

# Channel Processing Parameters

## 1A: Parameters

| Parameter | Description | Tool | Value | Unit |
|---|---|---|---|---|
| AHBHM | Array Induction Borehole Correction Mode | AIT-H | Compute Mud Resistivity | |
| AHSTA | Array Induction Tool Standoff | AIT-H | 1.56 | in |
| BARI(ISSBAR) | Barite Mud Presence Flag | Borehole | No | |
| BHS | Borehole Status (Open or Cased Hole) | Borehole | Open | |
| BHT | Bottom Hole Temperature | Borehole | 237.66 | degF |
| BS | Bit Size | WLSESSION | Depth Zoned | in |
| BSAL | Borehole Salinity | Borehole | 140000 | ppm |
| CALI_SHIFT | CALI Supplementary Offset | HDRS-H | 0.471 | in |
| CBLO | Casing Bottom (Logger) | WLSESSION | 1554 | ft |
| CSODDRL | Casing Outer Diameter - Zoned along driller depths | WLSESSION | 9.625 | in |
| DFD | Drilling Fluid Density | Borehole | 9.8 | lbm/gal |
| DFT_CATEGORY | Drilling Fluid Type | Borehole | Oil | |
| DHC | Density Hole Correction | HDRS-H | Bit Size | |
| FCD | Future Casing (Outer) Diameter | WLSESSION | 5.5 | in |
| FD | Fluid Density | Borehole | 1 | g/cm3 |
| FSAL | Formation Salinity | Borehole | 0 | ppm |
| GCSE_DOWN_PASS | Generalized Caliper Selection for WL Log Down Passes | Borehole | BS(RT) | |
| GCSE_UP_PASS | Generalized Caliper Selection for WL Log Up Passes | Borehole | CALI | |
| GRSE | Generalized Mud Resistivity Selection, from Measured or Computed Mud Resistivity | Borehole | AMF | |
| GTSE | Generalized Temperature Selection, from Measured or Computed Temperature | Borehole | CTEM | |
| HSCO | Hole Size Correction Option | HGNS-H | Yes | |
| MATR | Rock Matrix for Neutron Porosity Corrections | Borehole | LIMESTONE | |
| MDEN | Matrix Density for Density Porosity | Borehole | 2.71 | g/cm3 |
| SOCO | Standoff Correction Option | HGNS-H | Yes | |
| SPDR | SP Drift Per Foot | AIT-H | 0 | mV/ft |

## Depth Zone Parameters

| Parameter | Value | Start ( ft ) | Stop ( ft ) |
|---|---|---|---|
| BS | 12.25 | 1540 | 1553 |
| BS | 8.75 | 1553 | 9864 |

All depth are actual.

# Tool Control Parameters

## 1A: Parameters

| Parameter | Description | Tool | Value | Unit |
|---|---|---|---|---|
| HMCA_BOARD_TYPE | HMCA Board Type | HGNS-H | 1 | |
| HRGD_BOARD_TYPE | HRGD Board Type | HDRS-H | WITH_HET | |
| MAX_LOG_SPEED | Toolstring Maximum Logging Speed | WLSESSION | 3600 | ft/h |

# Repeat Pass 5" = 100'

## Pass Summary

| Run Name | Pass Objective | Direction | Top | Bottom | Start | Stop | DSC Mode | Depth Shift | Include Parallel Data |
|---|---|---|---|---|---|---|---|---|---|
| 1A | Repeat[2]:Up | Up | 9293.40 ft | 9863.63 ft | 23-Feb-2023 11:18:03 PM | 23-Feb-2023 11:29:40 PM | ON | 3.24 ft | No |
| 1A | Main[3]:Up | Up | 41.16 ft | 9870.33 ft | 23-Feb-2023 11:36:23 PM | 24-Feb-2023 2:35:46 AM | ON | 3.80 ft | Yes |

All depths are referenced to toolstring zero

## Log

Company:TALLGRASS HIGH PLAINS CARBON STORAGE, LLC Well:Juniper M-1

1A: Main[3]:Up:S009

Description: Triple Combo standard resolution template for Platform Express Format: Log ( TCOM 5in RA ) Index Scale: 5 in per 100 ft Index Unit: ft Index Type: Measured Depth Creation Date: 24-Feb-2023 02:44:32

ICV - Integrated Cement Volume every 10.00 (ft3)

ICV - Integrated Cement Volume every 100.00 (ft3)

IHV - Integrated Hole Volume every 10.00 (ft3)

IHV - Integrated Hole Volume every 100.00 (ft3)

TIME_1900 - Time Marked every 60.00 (s)

Main To Repeat

Repeat To Main

Standard Resolution Formation Photoelectric Factor (PEFZ) HDRS-H

0 10

Main To Repeat

Repeat To Main

Array Induction Two Foot Resistivity A90 (AHT90) AIT-H

0.2 ohm.m 2000

Main To Repeat

Repeat To Main

Density Standoff Correction (HDRA) HDRS-H

-0.05 g/cm3 0.45

Main To Repeat

Repeat To Main

Array Induction Two Foot Resistivity A10 (AHT10) AIT-H

0.2 ohm.m 2000

Main To Repeat

Repeat To Main

Caliper (HCAL) HDRS-H

6 in 16

Main To Repeat

Repeat To Main

Standard Resolution Density Standoff (DSOZ) HDRS-H

2.5 in 0

Main To Repeat

Repeat To Main

Array Induction Two Foot Resistivity A60 (AHT60) AIT-H

0.2 ohm.m 2000

Main To Repeat

Repeat To Main

Standard Resolution Density Porosity (DPHZ) HDRS-H

0.3 ft3/ft3 -0.1

Main To Repeat

Repeat To Main

Cable Tension (TENS)

10000 lbf 0

Main To Repeat

Repeat To Main

Array Induction Two Foot Resistivity A30 (AHT30) AIT-H

0.2 ohm.m 2000

Main To Repeat

Repeat To Main

Thermal Neutron Porosity (Ratio Method) in Selected Lithology (TNPH) HGNS-H

0.3 ft3/ft3 -0.1

Main To Repeat

Repeat To Main

Calibrated Gamma Ray (GR) HGNS-H

0 gAPI 150

Main To Repeat

Repeat To Main

Resistivity Standoff Standard Resolution (RSOZ) HDRS-H

Main To Repeat

Repeat To Main

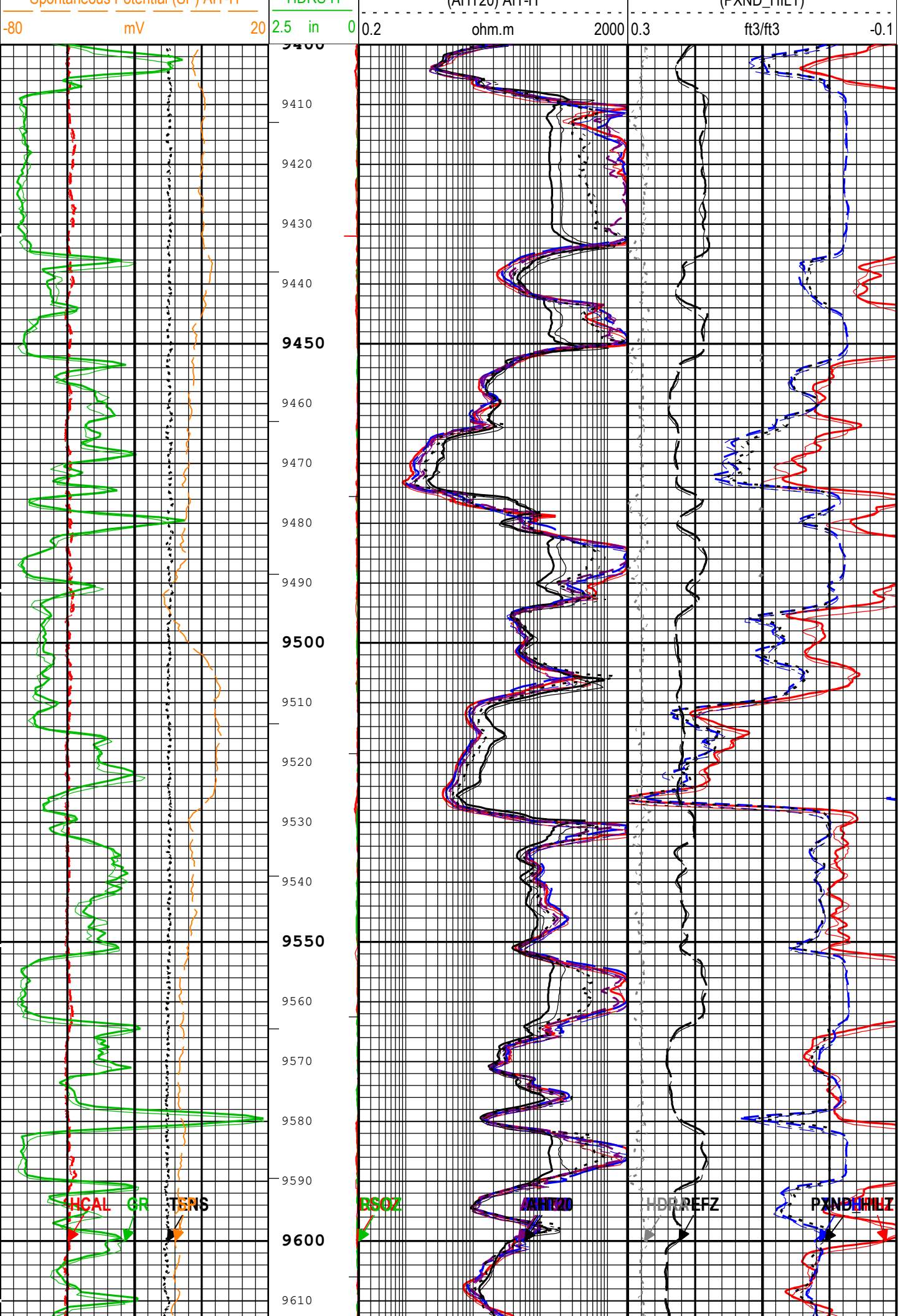
Array Induction Two Foot Resistivity A20 (AHT20) AIT-H

Main To Repeat

Repeat To Main

Crossplot Porosity for Neutron-Density (PXND_HILT)

Spontaneous Potential (SP) AIT-H


Spontaneous Potential (SP) AH-11
-80
mV
20
HDRS-11
2.5
in
0
(AHT20) AH-11
0.2
ohm.m
2000
(PXND_HILT)
0.3
ft3/ft3
-0.1
9400
9410
9420
9430
9440
9450
9460
9470
9480
9490
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HCAL
GR
TENS
BSOZ
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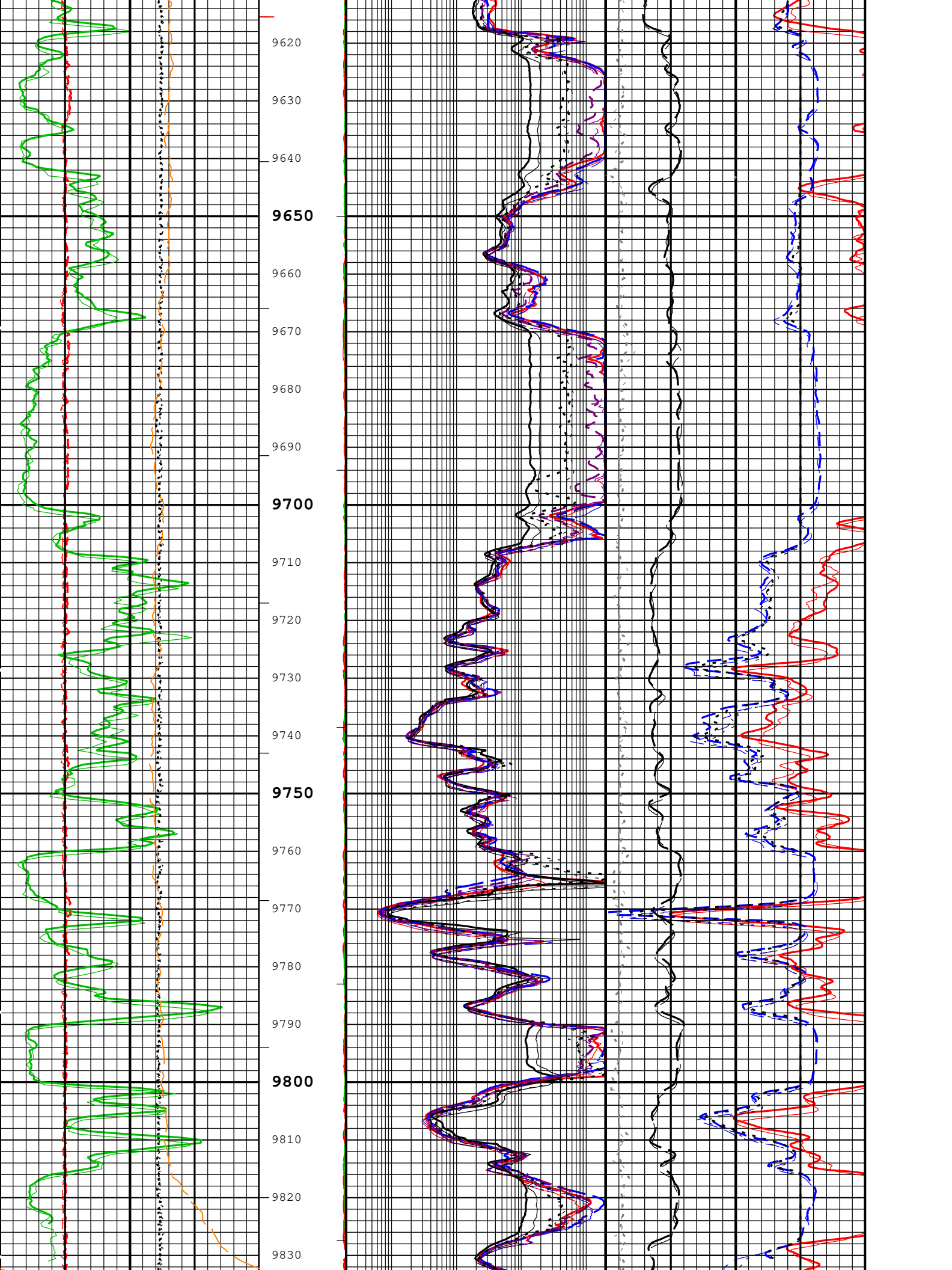
HDRA_REFZ
PXND_HILT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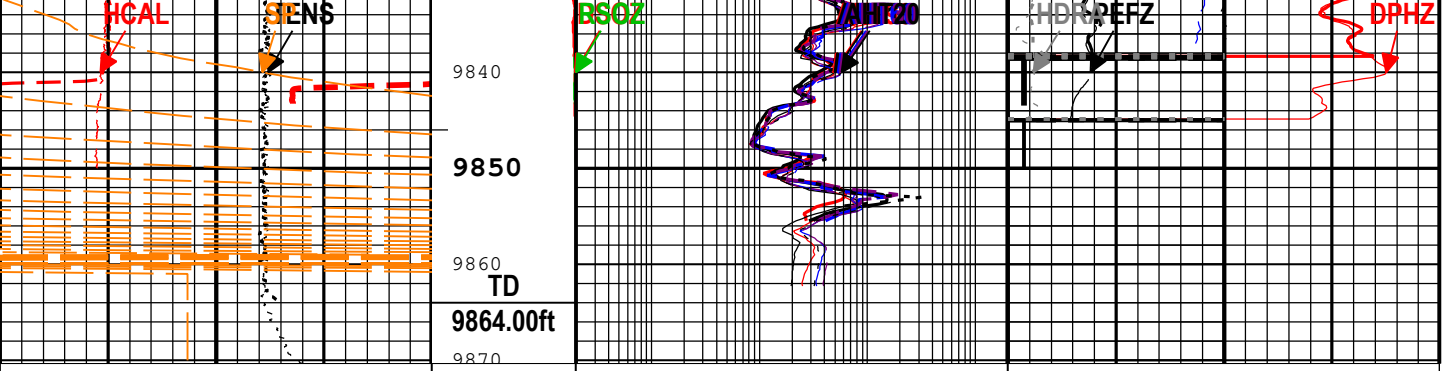



Main To Repeat

Repeat To Main

Caliper (HCAL) HDRS-H

6 in 16

Main To Repeat

Repeat To Main

Cable Tension (TENS)

10000 lbf 0

Main To Repeat

Repeat To Main

Calibrated Gamma Ray (GR) HGNS-H

0 gAPI 150

Spontaneous Potential (SP) AIT-H

-80 mV 20

Main To Repeat

Repeat To Main

Standard Resolution Density Standoff (DSOZ) HDRS-H

2.5 in 0

Main To Repeat

Repeat To Main

Resistivity Standoff Standard Resolution (RSOZ) HDRS-H

2.5 in 0

Main To Repeat

Repeat To Main

Array Induction Two Foot Resistivity A90 (AHT90) AIT-H

0.2 ohm.m 2000

Main To Repeat

Repeat To Main

Array Induction Two Foot Resistivity A10 (AHT10) AIT-H

0.2 ohm.m 2000

Main To Repeat

Repeat To Main

Array Induction Two Foot Resistivity A60 (AHT60) AIT-H

0.2 ohm.m 2000

Main To Repeat

Repeat To Main

Array Induction Two Foot Resistivity A30 (AHT30) AIT-H

0.2 ohm.m 2000

Main To Repeat

Repeat To Main

Array Induction Two Foot Resistivity A20 (AHT20) AIT-H

0.2 ohm.m 2000

Main To Repeat

Repeat To Main

Standard Resolution Density Porosity (DPHZ) HDRS-H

0.3 ft3/ft3 -0.1

Main To Repeat

Repeat To Main

Thermal Neutron Porosity (Ratio Method) in Selected Lithology (TNPH) HGNS-H

0.3 ft3/ft3 -0.1

Main To Repeat

Repeat To Main

Crossplot Porosity for Neutron-Density (PXND_HILT)

0.3 ft3/ft3 -0.1

Main To Repeat

Repeat To Main

Standard Resolution Formation Photoelectric Factor (PEFZ) HDRS-H

0 10

Main To Repeat

Repeat To Main

Density Standoff Correction (HDRA) HDRS-H

-0.05 g/cm3 0.45

TIME_1900 - Time Marked every 60.00 (s)

IHV - Integrated Hole Volume every 100.00 (ft3)

IHV - Integrated Hole Volume every 10.00 (ft3)

ICV - Integrated Cement Volume every 100.00 (ft3)

ICV - Integrated Cement Volume every 10.00 (ft3)

Description: Triple Combo standard resolution template for Platform Express Format: Log ( TCOM 5in RA ) Index Scale: 5 in per 100 ft Index Unit: ft Index Type: Measured Depth Creation Date: 24-Feb-2023 02:44:32

# Calibration Report

## AIT-H (Array Induction Tool - H) Calibration - Run 1A

Primary Equipment :

| | | |
|---|---|---|
| File code for AIT-HA Sonde Tool Element | AHIS | 152 |

## AIT Electronics Check - Thru Calibration Check

Before (Measured): 12:26:17 22-Feb-2023 Expired by 1 days

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| Thru Cal Mag - 0 | V | Before | ----- | 0.363 | 0.608 | 0.847 |
| Thru Cal Phase - 0 | deg | Before | ----- | 11.000 | 66.807 | 131.000 |
| Thru Cal Mag - 1 | V | Before | ----- | 0.762 | 1.246 | 1.778 |
| Thru Cal Phase - 1 | deg | Before | ----- | 10.000 | 65.696 | 130.000 |
| Thru Cal Mag - 2 | V | Before | ----- | 0.374 | 0.620 | 0.872 |
| Thru Cal Phase - 2 | deg | Before | ----- | 6.000 | 61.961 | 126.000 |
| Thru Cal Mag - 3 | V | Before | ----- | 0.422 | 0.702 | 0.986 |
| Thru Cal Phase - 3 | deg | Before | ----- | 5.000 | 61.182 | 125.000 |
| Thru Cal Mag - 4 | V | Before | ----- | 0.802 | 1.313 | 1.872 |
| Thru Cal Phase - 4 | deg | Before | ----- | -1.000 | 54.915 | 119.000 |
| Thru Cal Mag - 5 | V | Before | ----- | 1.173 | 1.908 | 2.737 |
| Thru Cal Phase - 5 | deg | Before | ----- | -3.000 | 53.016 | 117.000 |
| Thru Cal Mag - 6 | V | Before | ----- | 1.173 | 1.909 | 2.737 |
| Thru Cal Phase - 6 | deg | Before | ----- | -3.000 | 53.009 | 117.000 |
| Thru Cal Mag - 7 | V | Before | ----- | 0.849 | 1.366 | 1.981 |
| Thru Cal Phase - 7 | deg | Before | ----- | -7.000 | 49.304 | 113.000 |
| SPA Zero | mV | Before | ----- | -50.000 | -0.055 | 50.000 |
| SPA Plus | mV | Before | ----- | 941.000 | 991.955 | 1040.000 |
| Temperature Zero | V | Before | ----- | -0.050 | 0.000 | 0.050 |
| Temperature Plus | V | Before | ----- | 0.870 | 0.919 | 0.960 |

## HDRS-H (HILT Density and Rxo Sonde, 150 degC) Calibration - Run 1A

Primary Equipment :

| | | |
|---|---|---|
| HILT High-Resolution Control Cartridge, 150 degC | HRCC-H | 4935 |
| HILT Resistivity Gamma-Ray Density Device, 150 degC | HRGD-H | 5789 |

Auxiliary Equipment :

| | | |
|---|---|---|
| HRDD Backscatter Detector | Backscatter | 41150 |
| HRDD Long Spacing Detector | Long Spacing | 72767 |
| HRDD Short Spacing Detector | Short Spacing | 72767 |
| Cesium 137 Gamma-Ray Logging Source | GSR-J | 5702 |
| HILT High-Resolution Control Cartridge, 150 degC | HRCC-H | 4935 |
| HILT High-Resolution Mechanical Sonde, 150 degC | HRMS-H | 3995 |

Calibration Parameter :

| | |
|---|---|
| Small Ring Size (Caliper Calibration Small Ring) | 8.00 |
| Large Ring Size (Caliper Calibration Large Ring) | 12.00 |

## HDRS Caliper Calibration - Caliper Accumulations

Before (Measured): 10:56:37 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| Small Ring | in | Before | 8.00 | 6.00 | 8.18 | 10.00 |
| Large Ring | in | Before | 12.00 | 9.00 | 12.12 | 15.00 |

## HDRS Density Calibration - Inversion Results

Master (EEPROM): 10:38:08 08-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| Rho Aluminum | g/cm3 | Master | 2.596 | 2.586 | 2.598 | 2.606 |
| Rho Magnesium | g/cm3 | Master | 1.686 | 1.676 | 1.686 | 1.696 |
| Pe Aluminum | | Master | 2.570 | 2.470 | 2.551 | 2.670 |
| Pe Magnesium | | Master | 2.650 | 2.550 | 2.632 | 2.750 |

## HDRS Density Calibration - Deviation Summary

Master (EEPROM): 10:38:08 08-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| BS Average Deviation | % | Master | 0 | -0.6000 | 0.3241 | 0.6000 |
| BS Max Deviation | % | Master | 0 | -1.6000 | 0.7925 | 1.6000 |
| SS Average Deviation | % | Master | 0 | -1.0000 | 0.3647 | 1.0000 |
| SS Max Deviation | % | Master | 0 | -2.5000 | 0.8414 | 2.5000 |
| LS Average Deviation | % | Master | 0 | -1.5000 | 0.7069 | 1.5000 |
| LS Max Deviation | % | Master | 0 | -3.5000 | 1.7099 | 3.5000 |

## HDRS Density Calibration - Background Summary

Master (EEPROM): 10:38:08 08-Feb-2023 Before (Measured): 10:55:06 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| BS Window Ratio | | Master | 1.0000 | ----- | 0.7280 | ----- |
| | | Before | 0.7280 | 0.6916 | 0.7301 | 0.7644 |
| | | Before-Master | ----- | ----- | 0.0021 | ----- |
| BS Window Sum | 1/s | Master | 1 | ----- | 30131 | ----- |
| | | Before | 30131 | 28625 | 30088 | 31638 |
| | | Before-Master | ----- | ----- | -43 | ----- |
| SS Window Ratio | | Master | 1.0000 | ----- | 0.4843 | ----- |
| | | Before | 0.4843 | 0.4601 | 0.4861 | 0.5086 |
| | | Before-Master | ----- | ----- | 0.0018 | ----- |
| SS Window Sum | 1/s | Master | 1 | ----- | 12552 | ----- |
| | | Before | 12552 | 11924 | 12519 | 13179 |
| | | Before-Master | ----- | ----- | -33 | ----- |
| LS Window Ratio | | Master | 1.0000 | ----- | 0.3005 | ----- |
| | | Before | 0.3005 | 0.2854 | 0.3007 | 0.3155 |
| | | Before-Master | ----- | ----- | 0.0002 | ----- |
| LS Window Sum | 1/s | Master | 1 | ----- | 1503 | ----- |
| | | Before | 1503 | 1428 | 1495 | 1578 |
| | | Before-Master | ----- | ----- | -8 | ----- |

## HDRS Density Calibration - Photo-multiplier High Voltages

Master (EEPROM): 10:38:08 08-Feb-2023 Before (Measured): 10:55:06 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| BS PM High Voltage | V | Master | ----- | 1000.0 | 1465.3 | 2400.0 |
| | | Before | ----- | 1000.0 | 1485.9 | 2400.0 |
| | | Before-Master | ----- | -100.0 | 20.6 | 100.0 |
| SS PM High Voltage | V | Master | ----- | 1000.0 | 1606.2 | 2400.0 |
| | | Before | ----- | 1000.0 | 1618.0 | 2400.0 |
| | | Before-Master | ----- | -100.0 | 11.8 | 100.0 |
| LS PM High Voltage | V | Master | ----- | 1000.0 | 1379.5 | 2400.0 |
| | | Before | ----- | 1000.0 | 1384.5 | 2400.0 |
| | | Before-Master | ----- | -100.0 | 5.0 | 100.0 |

## HDRS Density Calibration - Crystal Quality Resolutions

Master (EEPROM): 10:38:08 08-Feb-2023 Before (Measured): 10:55:06 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| BS Crystal Resolution | % | Master | 11.00 | 5.00 | 11.96 | 13.70 |
| | | Before | 11.00 | 5.00 | 12.10 | 13.70 |
| | | Before-Master | ----- | -1.00 | 0.14 | 1.00 |
| SS Crystal Resolution | % | Master | 10.00 | 5.00 | 9.43 | 12.00 |
| | | Before | 10.00 | 5.00 | 9.61 | 12.00 |
| | | Before-Master | ----- | -1.00 | 0.18 | 1.00 |
| LS Crystal Resolution | % | Master | 10.00 | 5.00 | 8.45 | 12.00 |
| | | Before | 10.00 | 5.00 | 8.40 | 12.00 |
| | | Before-Master | ----- | -1.00 | -0.05 | 1.00 |

## HDRS Density Calibration - Uncalibrated Count Rate During Background

Master (EEPROM): 10:38:08 08-Feb-2023 Before (Measured): 10:55:06 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| BS Uncalibrated Count Rate - 0 | 1/s | Master | 8900.00 | 5200.00 | 8332.85 | 11500.00 |
| | | Before | 8900.00 | 5200.00 | 8335.79 | 11500.00 |
| | | Before-Master | ----- | ----- | 2.94 | ----- |

| | | | | | | |
|---|---|---|---|---|---|---|
| BS Uncalibrated Count Rate - 1 | 1/s | Master | 10900.00 | 6400.00 | 10352.71 | 13500.00 |
| | | Before | 10900.00 | 6400.00 | 10334.91 | 13500.00 |
| | | Before-Master | ----- | ----- | -17.80 | ----- |
| BS Uncalibrated Count Rate - 2 | 1/s | Master | 12300.00 | 6800.00 | 11445.55 | 15000.00 |
| | | Before | 12300.00 | 6800.00 | 11417.24 | 15000.00 |
| | | Before-Master | ----- | ----- | -28.31 | ----- |
| BS Uncalibrated Count Rate - 3 | 1/s | Master | 4800.00 | 2800.00 | 4576.85 | 6000.00 |
| | | Before | 4800.00 | 2800.00 | 4561.43 | 6000.00 |
| | | Before-Master | ----- | ----- | -15.42 | ----- |
| SS Uncalibrated Count Rate - 0 | 1/s | Master | 2030.00 | 1280.00 | 2114.02 | 3000.00 |
| | | Before | 2030.00 | 1280.00 | 2115.53 | 3000.00 |
| | | Before-Master | ----- | ----- | 1.51 | ----- |
| SS Uncalibrated Count Rate - 1 | 1/s | Master | 2120.00 | 1310.00 | 2087.79 | 3000.00 |
| | | Before | 2120.00 | 1310.00 | 2081.99 | 3000.00 |
| | | Before-Master | ----- | ----- | -5.80 | ----- |
| SS Uncalibrated Count Rate - 2 | 1/s | Master | 4320.00 | 2490.00 | 3985.04 | 5500.00 |
| | | Before | 4320.00 | 2490.00 | 3969.21 | 5500.00 |
| | | Before-Master | ----- | ----- | -15.83 | ----- |
| SS Uncalibrated Count Rate - 3 | 1/s | Master | 4500.00 | 2400.00 | 4364.75 | 6000.00 |
| | | Before | 4500.00 | 2400.00 | 4352.45 | 6000.00 |
| | | Before-Master | ----- | ----- | -12.30 | ----- |
| LS Uncalibrated Count Rate - 0 | 1/s | Master | 160.00 | 90.00 | 166.26 | 250.00 |
| | | Before | 160.00 | 90.00 | 166.23 | 250.00 |
| | | Before-Master | ----- | ----- | -0.03 | ----- |
| LS Uncalibrated Count Rate - 1 | 1/s | Master | 400.00 | 230.00 | 391.54 | 500.00 |
| | | Before | 400.00 | 230.00 | 387.54 | 500.00 |
| | | Before-Master | ----- | ----- | -4.00 | ----- |
| LS Uncalibrated Count Rate - 2 | 1/s | Master | 350.00 | 230.00 | 391.63 | 500.00 |
| | | Before | 350.00 | 230.00 | 388.72 | 500.00 |
| | | Before-Master | ----- | ----- | -2.91 | ----- |
| LS Uncalibrated Count Rate - 3 | 1/s | Master | 530.00 | 330.00 | 553.34 | 700.00 |
| | | Before | 530.00 | 330.00 | 552.76 | 700.00 |
| | | Before-Master | ----- | ----- | -0.58 | ----- |

## HDRS Density Calibration - Uncalibrated Count Rate During Aluminum Air

Master (EEPROM): 10:38:08 08-Feb-2023 Before (Measured): 10:55:06 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| BS Uncalibrated Alu-Air Count Rate - 0 | 1/s | Master | ----- | ----- | 0.00 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| BS Uncalibrated Alu-Air Count Rate - 1 | 1/s | Master | ----- | ----- | 234128.20 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| BS Uncalibrated Alu-Air Count Rate - 2 | 1/s | Master | ----- | ----- | 212206.80 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| BS Uncalibrated Alu-Air Count Rate - 3 | 1/s | Master | ----- | ----- | 0.00 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| SS Uncalibrated Alu-Air Count Rate - 0 | 1/s | Master | ----- | ----- | 0.00 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| SS Uncalibrated Alu-Air Count Rate - 1 | 1/s | Master | ----- | ----- | 25492.24 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| SS Uncalibrated Alu-Air Count Rate - 2 | 1/s | Master | ----- | ----- | 25706.81 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| SS Uncalibrated Alu-Air Count Rate - 3 | 1/s | Master | ----- | ----- | 22055.13 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| LS Uncalibrated Alu-Air Count Rate - 0 | 1/s | Master | ----- | ----- | 0.00 | ----- |
| | | Before | ----- | ----- | ----- | ----- |

| | | | | | | |
|---|---|---|---|---|---|---|
| LS Uncalibrated Alu-Air Count Rate - 1 | 1/s | Master | ----- | ----- | 2172.20 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| LS Uncalibrated Alu-Air Count Rate - 2 | 1/s | Master | ----- | ----- | 987.15 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| LS Uncalibrated Alu-Air Count Rate - 3 | 1/s | Master | ----- | ----- | 1053.85 | ----- |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |

## HDRS Density Calibration - Low energy window ratio to window 1 During Background

Master (EEPROM): 10:38:08 08-Feb-2023 Before (Measured): 10:55:06 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| BS Low energy window ratio to window 1 | % | Master | 2.8000 | 0.1000 | 2.1001 | 10.0000 |
| | | Before | 2.8000 | 0.1000 | 2.3458 | 10.0000 |
| | | Before-Master | ----- | ----- | 0.2457 | ----- |
| SS Low energy window ratio to window 1 | % | Master | 4.2000 | 0.1000 | 3.6644 | 10.0000 |
| | | Before | 4.2000 | 0.1000 | 3.7505 | 10.0000 |
| | | Before-Master | ----- | ----- | 0.0861 | ----- |
| LS Low energy window ratio to window 1 | % | Master | 6.0000 | 0.1000 | 3.8297 | 10.0000 |
| | | Before | 6.0000 | 0.1000 | 3.8986 | 10.0000 |
| | | Before-Master | ----- | ----- | 0.0689 | ----- |

## HDRS MCFL Calibration - MCFL Accumulations

Before (Measured): 22:09:49 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| Main Resistivity | ohm.m | Before | 3875 | 3565 | 3865 | 4185 |
| Deep Resistivity | ohm.m | Before | 3830 | 3524 | 3822 | 4136 |
| Shallow Resistivity | ohm.m | Before | 3830 | 3524 | 3827 | 4136 |

## HGNS-H (HILT Gamma-Ray and Neutron Sonde, 150 degC) Calibration - Run 1A

Primary Equipment :

| | | |
|---|---|---|
| HILT Gamma-Ray and Neutron Sonde, 150 degC | HGNS-H | 3964 |

Auxiliary Equipment :

| | | |
|---|---|---|
| HGNS Accelerometer, 150 degC | HACCZ-H | 4166 |
| AmBe Neutron Logging Source | NSR-F | 5070 |

Calibration Parameter :

| | |
|---|---|
| Water Temperature | |
| Housing Size | |
| JIG-BKG (Jig minus background reference) | 165 |

## HGNS Accelerometer Calibration - Accelerometer Accumulations

Before (Measured): 22:09:29 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| AZ Vertical Measurement | ft/s2 | Before | 32.2 | 31.5 | 32.1 | 32.8 |

## HGNS Accelerometer EEPROM - Accelerometer EEPROM Read

Master (EEPROM): 17:00:00 14-Jul-2005

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| Accelerometer Manufacturer | | Master | ----- | ----- | QAT_160 | ----- |
| Accelerometer Reference Temperature | degF | Master | ----- | 30.2 | 77.0 | 122.0 |
| Accelerometer Coefficients - 0 | | Master | ----- | ----- | 11397.000 | ----- |
| Accelerometer Coefficients - 1 | | Master | ----- | ----- | -4.294 | ----- |
| Accelerometer Coefficients - 2 | | Master | ----- | ----- | -0.010 | ----- |
| Accelerometer Coefficients - 3 | | Master | ----- | ----- | 0.000 | ----- |
| Accelerometer Coefficients - 4 | | Master | ----- | ----- | 2.740 | ----- |
| Accelerometer Coefficients - 5 | | Master | ----- | ----- | 0.000 | ----- |
| Accelerometer Coefficients - 6 | | Master | ----- | ----- | 0.000 | ----- |
| Accelerometer Coefficients - 7 | | Master | ----- | ----- | 0.000 | ----- |

| | | | | | | |
|---|---|---|---|---|---|---|
| Accelerometer Coefficients - 8 | | Master | ----- | ----- | 299.000 | ----- |
| Accelerometer Coefficients - 9 | | Master | ----- | ----- | 0.994 | ----- |

## HGNS Neutron Calibration - HGNS Neutron Accumulations

Master (EEPROM): 14:04:24 01-Sep-2022 Before (Measured): 10:53:07 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| Near Zero Measurement | 1/s | Master | 0 | 10.0 | 28.6 | 40.0 |
| | | Before | 0 | 10.0 | 28.4 | 40.0 |
| | | Before-Master | ----- | -4.3 | -0.2 | 4.3 |
| Far Zero Measurement | 1/s | Master | 0 | 10.0 | 29.5 | 40.0 |
| | | Before | 0 | 10.0 | 27.9 | 40.0 |
| | | Before-Master | ----- | -4.4 | -1.6 | 4.4 |
| Near Plus Measurement | 1/s | Master | 6031.0 | 4700.0 | 4897.0 | 6900.0 |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| Far Plus Measurement | 1/s | Master | 2793.0 | 1900.0 | 2097.0 | 2900.0 |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| Near Corrected Plus Measurement | 1/s | Master | ----- | 4700.0 | 4839.0 | 6900.0 |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |
| Far Corrected Plus Measurement | 1/s | Master | ----- | 1900.0 | 2048.0 | 2900.0 |
| | | Before | ----- | ----- | ----- | ----- |
| | | Before-Master | ----- | ----- | ----- | ----- |

## HGNS Gamma-Ray Calibration - Gamma-Ray Accumulations

Before (Measured): 11:03:53 23-Feb-2023

| Measurement | Unit | Phase | Nominal | Low Limit | Actual | High Limit |
|---|---|---|---|---|---|---|
| RGR Zero Measurement | gAPI | Before | 30.0 | 0 | 91.0 | 120.0 |
| RGR Plus Measurement | gAPI | Before | 185.4 | 157.1 | 171.5 | 206.3 |
| GR Calibration Gain | | Before | 0.89 | 0.80 | 0.96 | 1.05 |

| | |
|---|---|
| Company: | TALLGRASS HIGH PLAINS CARBON STORAGE, L |
| Well: | Juniper M-1 |
| Field: | Wildcat |
| County: | Laramie |
| State: | Wyoming |

# TCOM

## 1A

## Main Pass 1" = 100'

### Integration Summary

| Output Channel(s) | Output Description | Input Parameter | Output Value | Unit |
|---|---|---|---|---|
| IHV | Integrated Hole Volume | GCSE_UP_PASS | 3376.66 | ft3 |
| ICV | Integrated Cement Volume | GCSE_UP_PASS, FCD | 2004.53 | ft3 |

### Pass Summary

| Run Name | Pass Objective | Direction | Top | Bottom | Start | Stop | DSC Mode | Depth Shift | Include Parallel Data |
|---|---|---|---|---|---|---|---|---|---|
| 1A | Main[3]:Up | Up | 41.16 ft | 9870.33 ft | 23-Feb-2023 11:36:23 PM | 24-Feb-2023 2:35:46 AM | ON | 3.80 ft | Yes |

All depths are referenced to toolstring zero

### Log

Company:TALLGRASS HIGH PLAINS CARBON STORAGE, LLC Well:Juniper M-1

1A: Main[3]:Up:S009

Description: Triple Combo standard resolution template for Platform Express Format: Log ( TCOM 1in ) Index Scale: 1 in per 100 ft Index Unit: ft Index Type: Measured Depth Creation Date: 24-Feb-2023 02:44:40

| Channel | Source | Sampling |
|---|---|---|
| AT10 | AIT-H:AHIS:AHIS | 3in |
| AT20 | AIT-H:AHIS:AHIS | 3in |
| AT30 | AIT-H:AHIS:AHIS | 3in |

| | | |
|---|---|---|
| AT60 | AIT-H:AHIS:AHIS | 3in |
| AT90 | AIT-H:AHIS:AHIS | 3in |
| CALI | HDRS-H:HRCC-H:HRCC-H | 1in |
| DPHZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| DSOZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| GR_CAL | HGNS-H:HGNS-H:HGNS-H | 6in |
| HDRA | HDRS-H:HRMS-H:HRGD-H | 2in |
| ICV | Borehole | 6in - RT |
| IHV | Borehole | 6in - RT |
| PEFZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| PXND | PEQL | 6in |
| RSOZ | HDRS-H:HRMS-H:HRGD-H | 2in |
| SP | AIT-H:AHIS:AHIS | 6in |
| TENS | WLWorkflow | 1in |
| TIME_1900 | WLWorkflow | 0.1in |
| TNPH | HGNS-H:HGNS-H:HGNS-H | 6in |

IHV - Integrated Hole Volume every 100.00 (ft3)

ICV - Integrated Cement Volume every 10.00 (ft3)

ICV - Integrated Cement Volume every 100.00 (ft3)

IHV - Integrated Hole Volume every 10.00 (ft3)

TIME_1900 - Time Marked every 60.00 (s)

Caliper (HCAL) HDRS-H
6 in 16

Spontaneous Potential (SP) AIT-H
-80 mV 20

Cable Tension (TENS)
10000 lbf 0

Calibrated Gamma Ray (GR) HGNS-H
0 gAPI 150

Standard Resolution Density Standoff (DSOZ) HDRS-H
2.5 in 0

Resistivity Standoff Standard Resolution (RSOZ) HDRS-H
2.5 in 0

DSOA

RSOA

Array Induction Two Foot Resistivity A10 (AHT10) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A20 (AHT20) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A30 (AHT30) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A60 (AHT60) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A90 (AHT90) AIT-H
0.2 ohm.m 2000

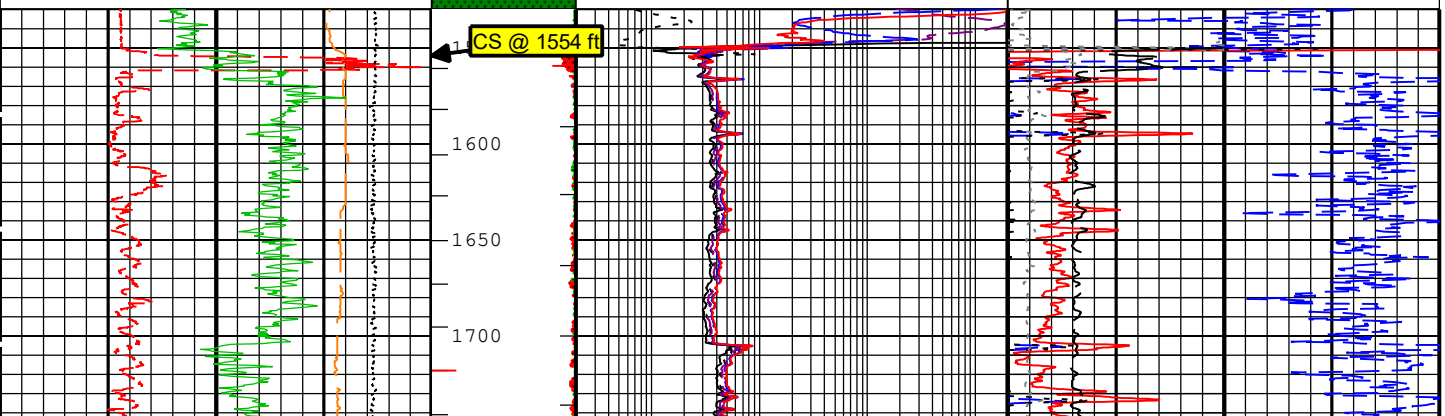
Density Standoff Correction (HDRA) HDRS-H
-0.05 g/cm3 0.45

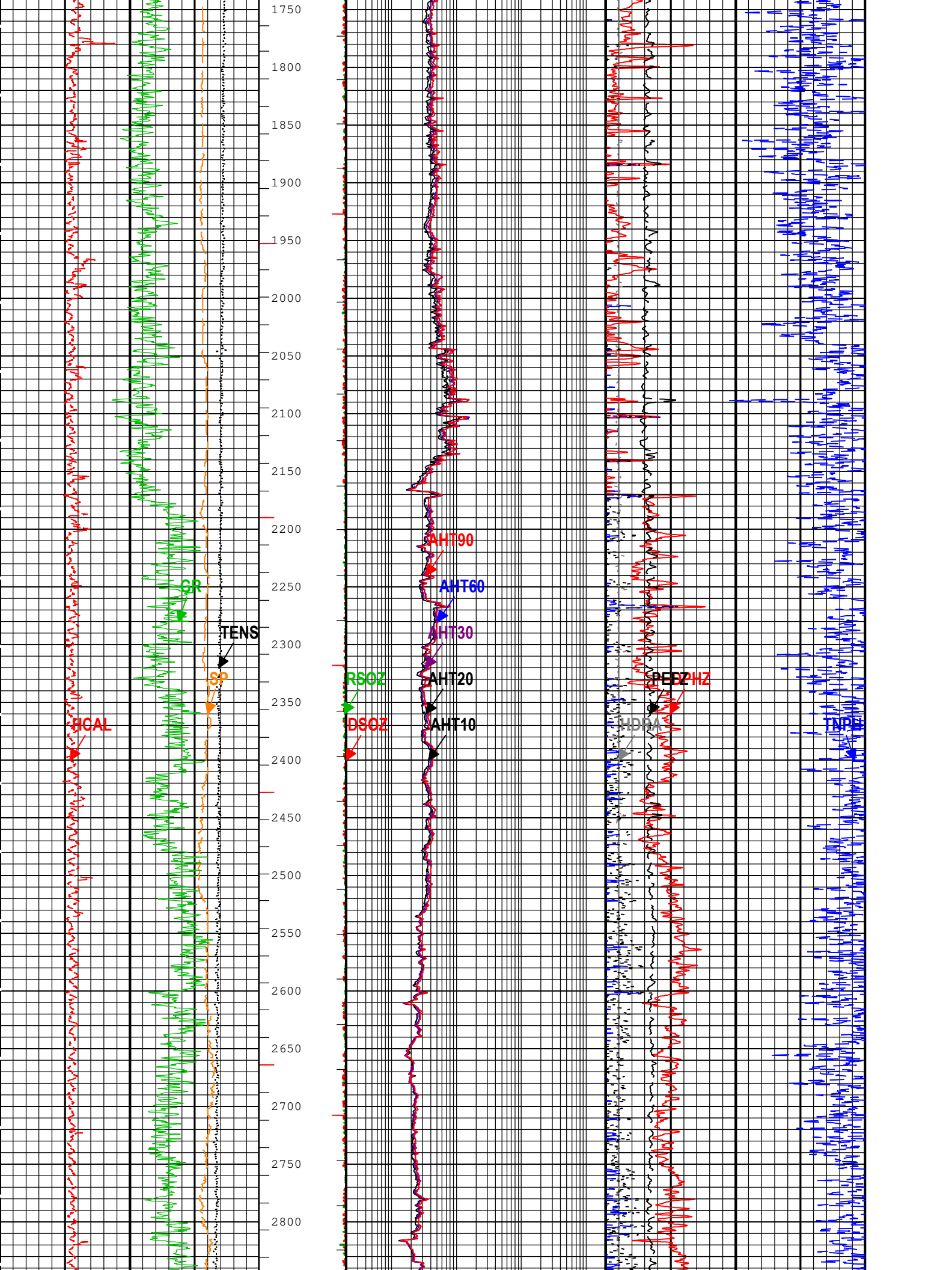
Standard Resolution Formation Photoelectric Factor (PEFZ) HDRS-H
0 10

Thermal Neutron Porosity (Ratio Method) in Selected Lithology (TNPH) HGNS-H
0.3 ft3/ft3 -0.1

Standard Resolution Density Porosity (DPHZ) HDRS-H
0.3 ft3/ft3 -0.1

Crossplot Porosity for Neutron-Density (PXND_HILT)
0.3 ft3/ft3 -0.1

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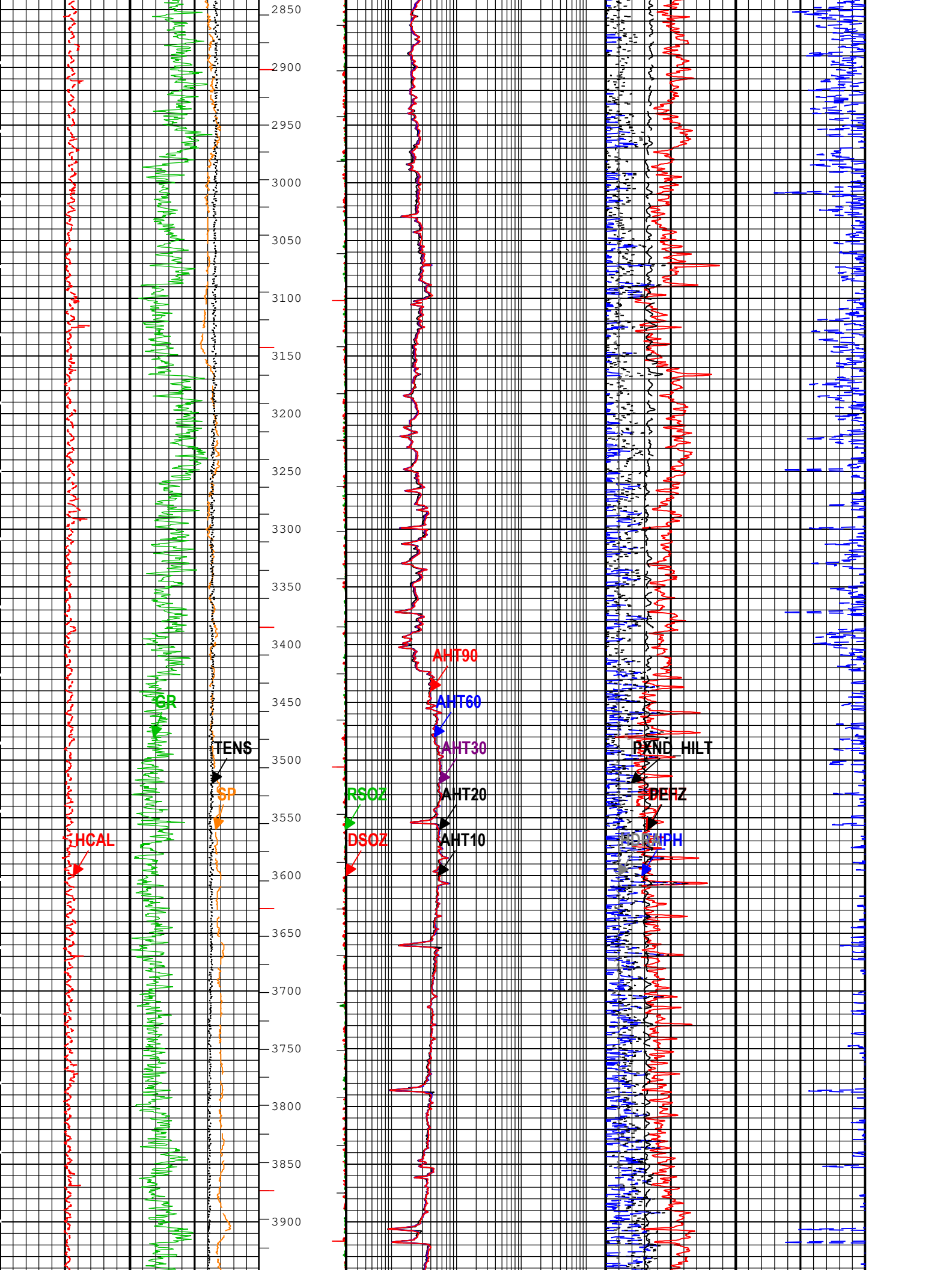

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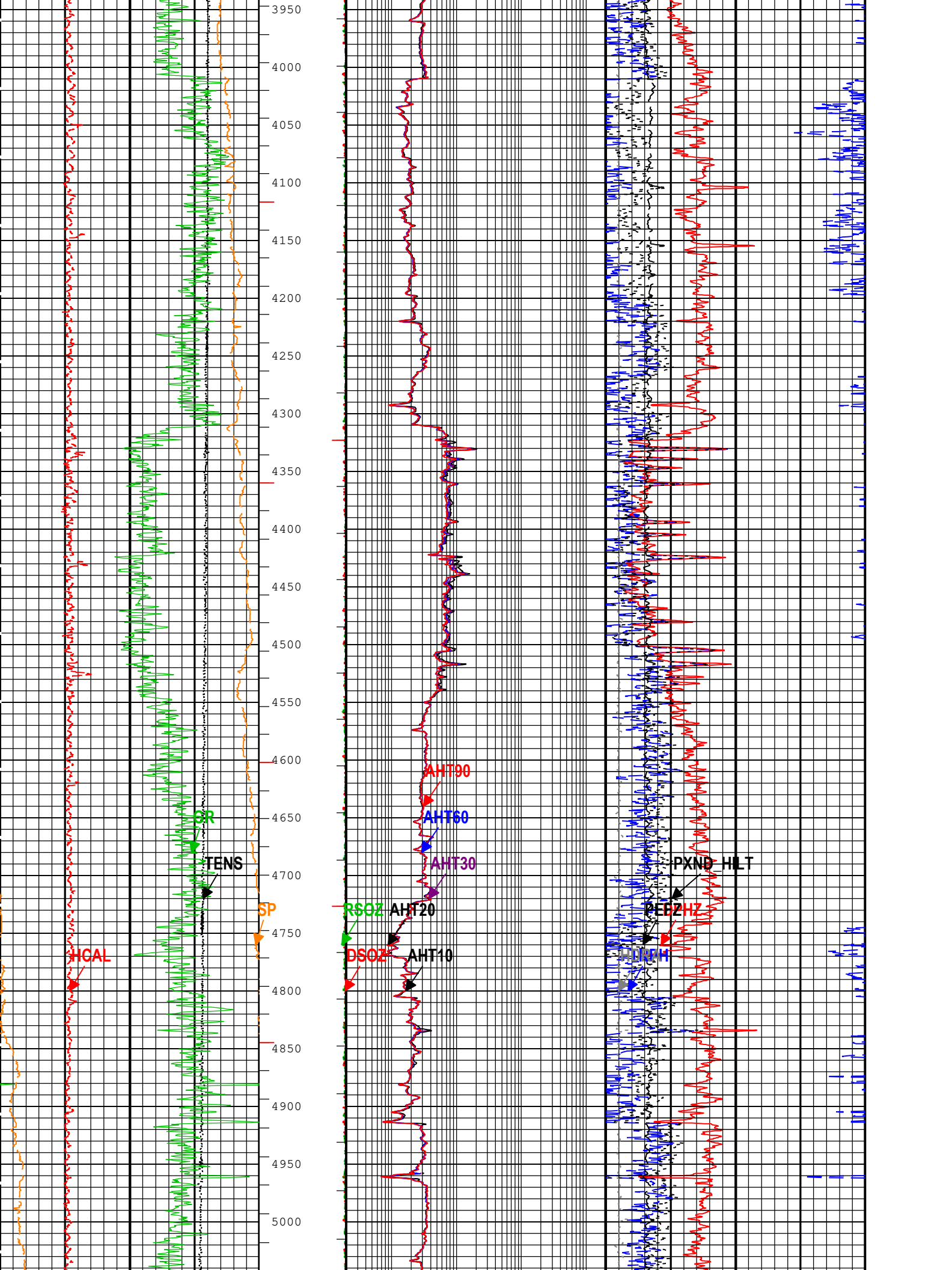
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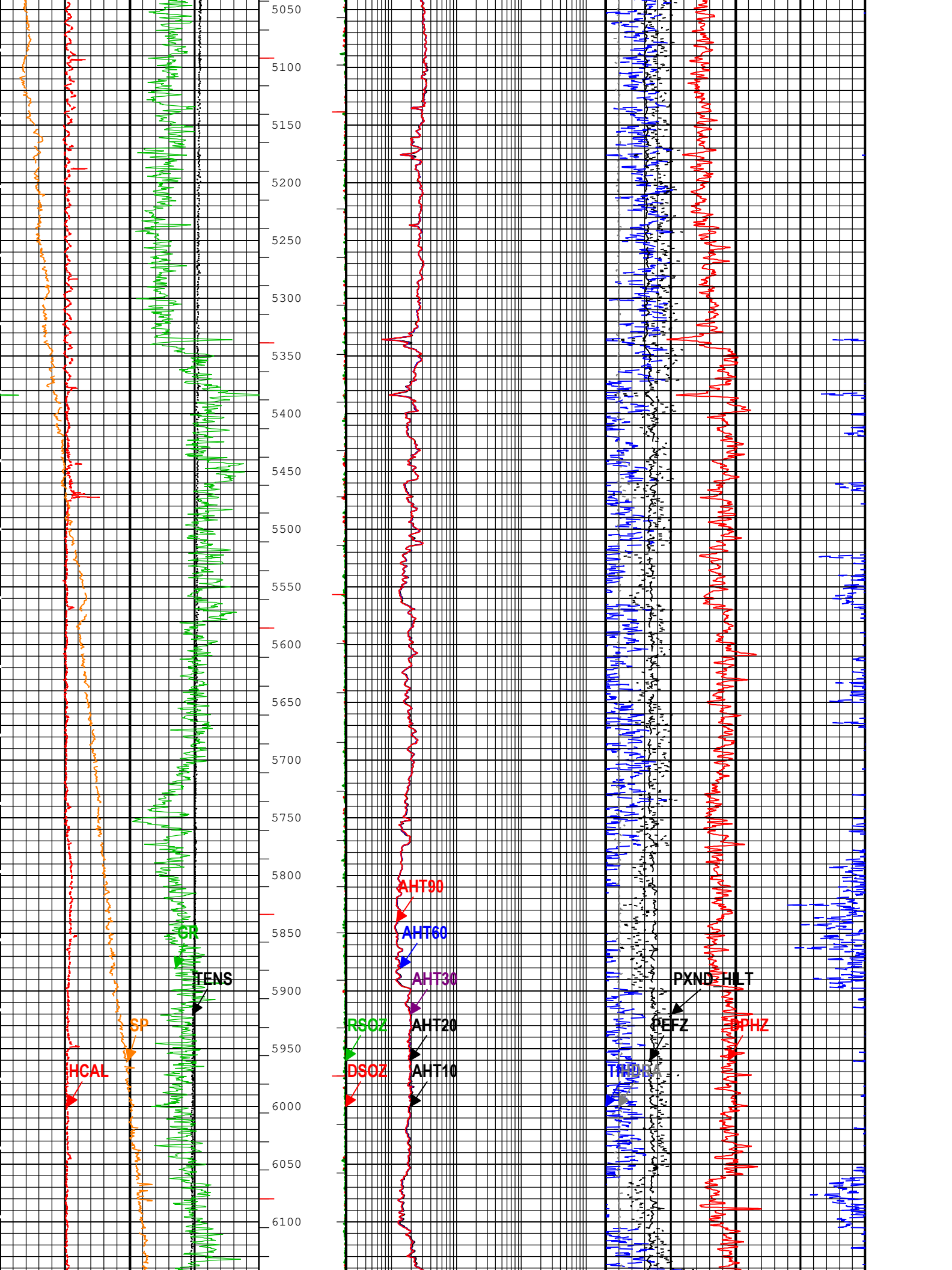
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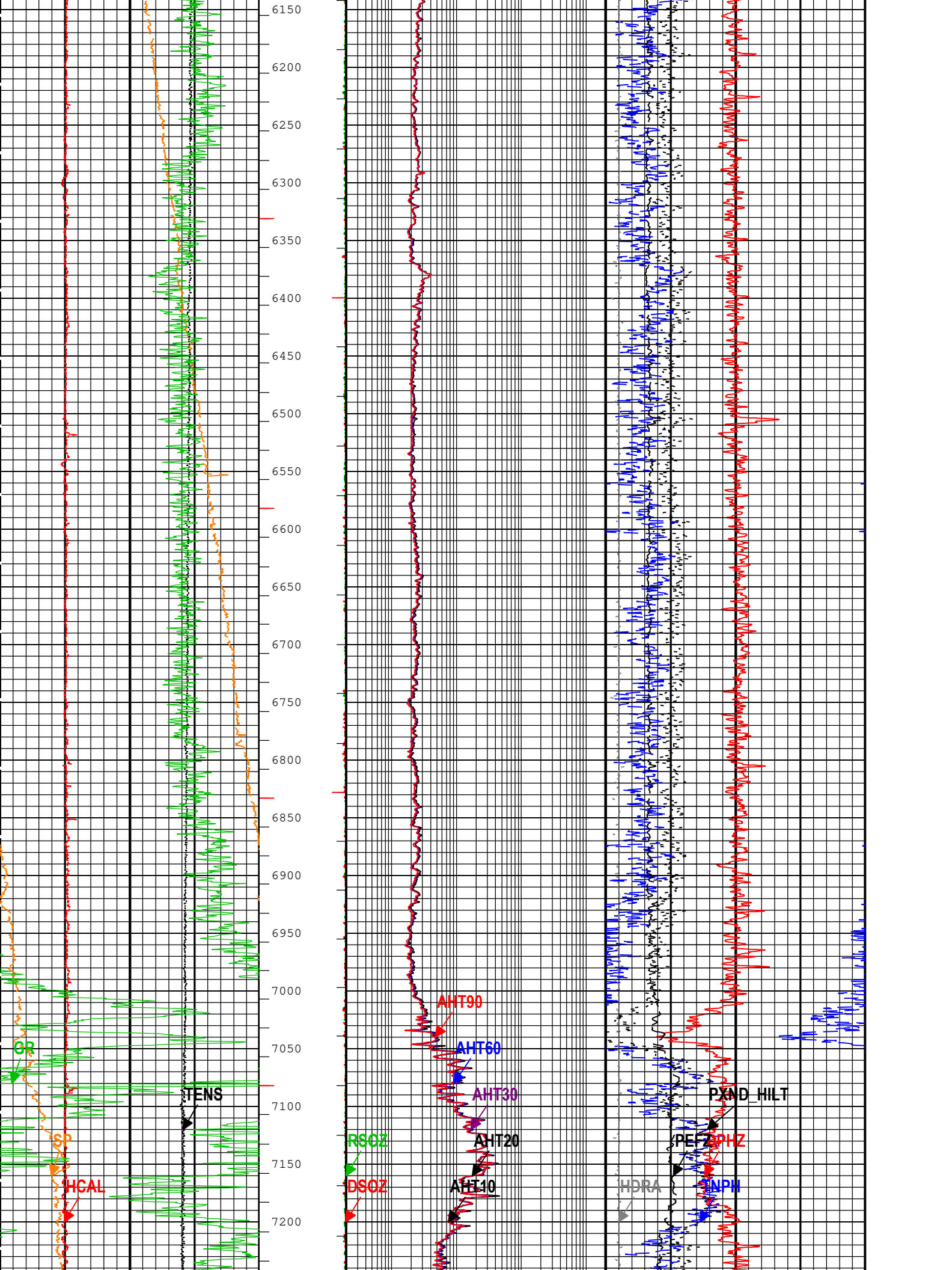
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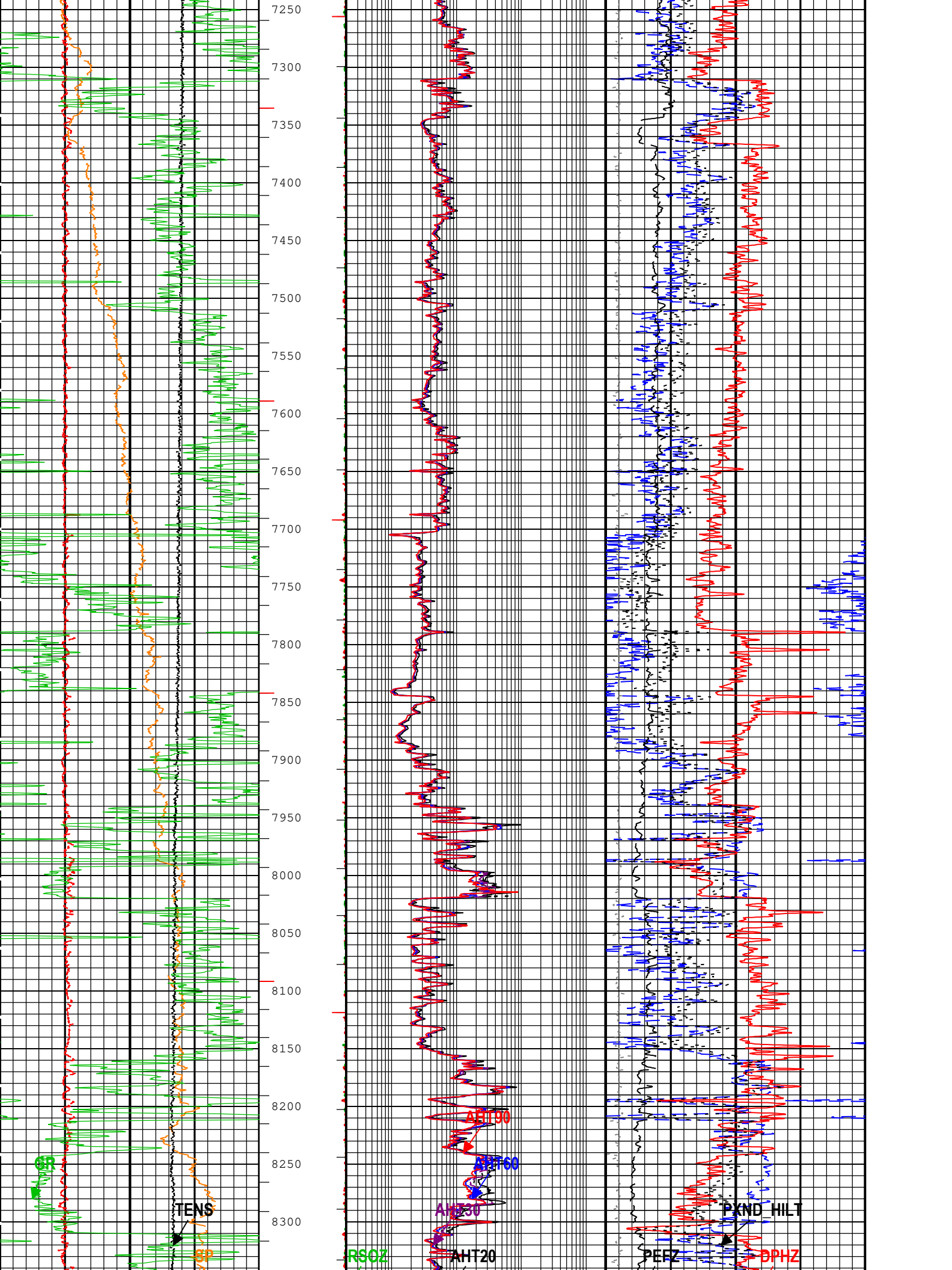
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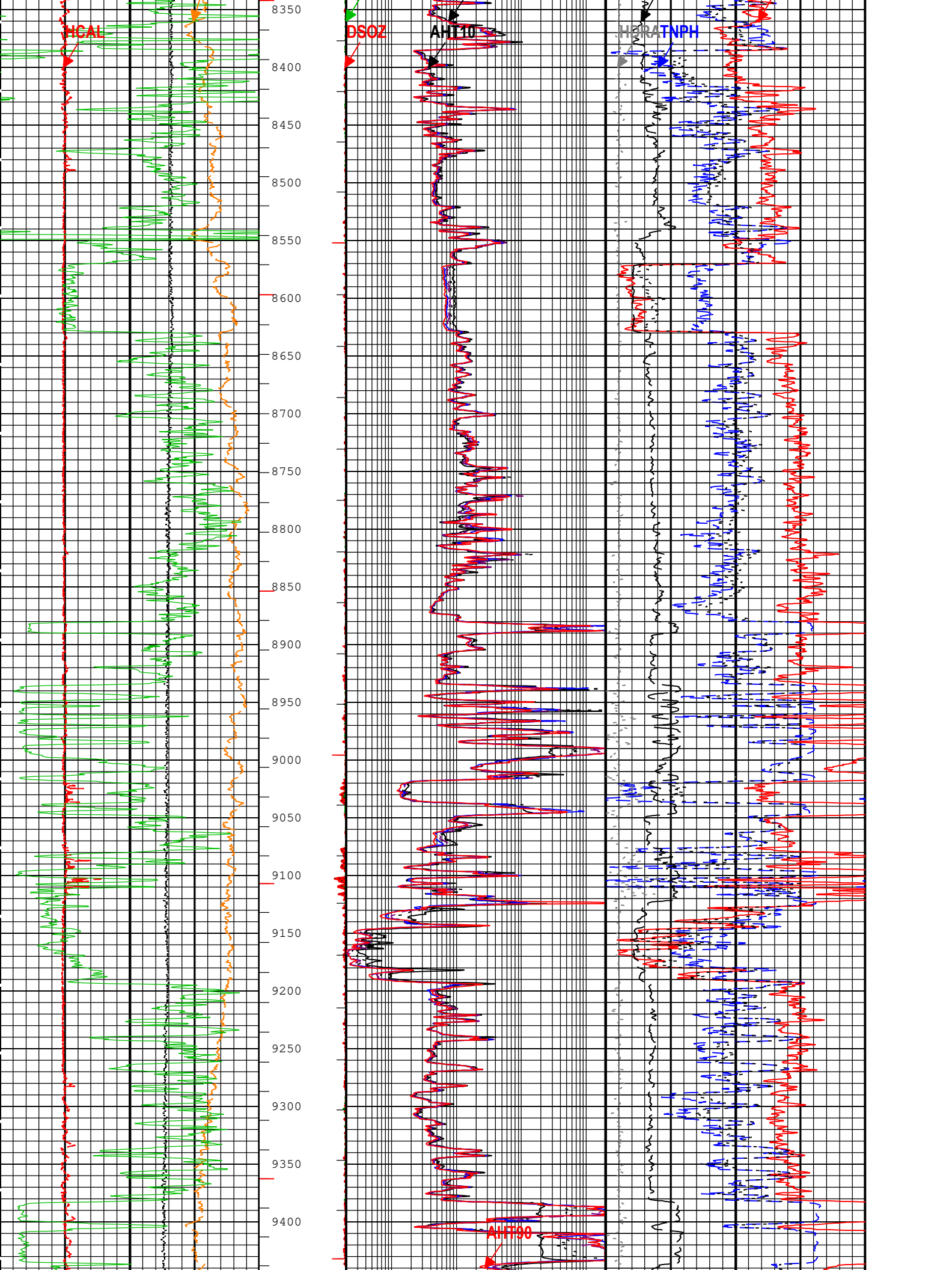
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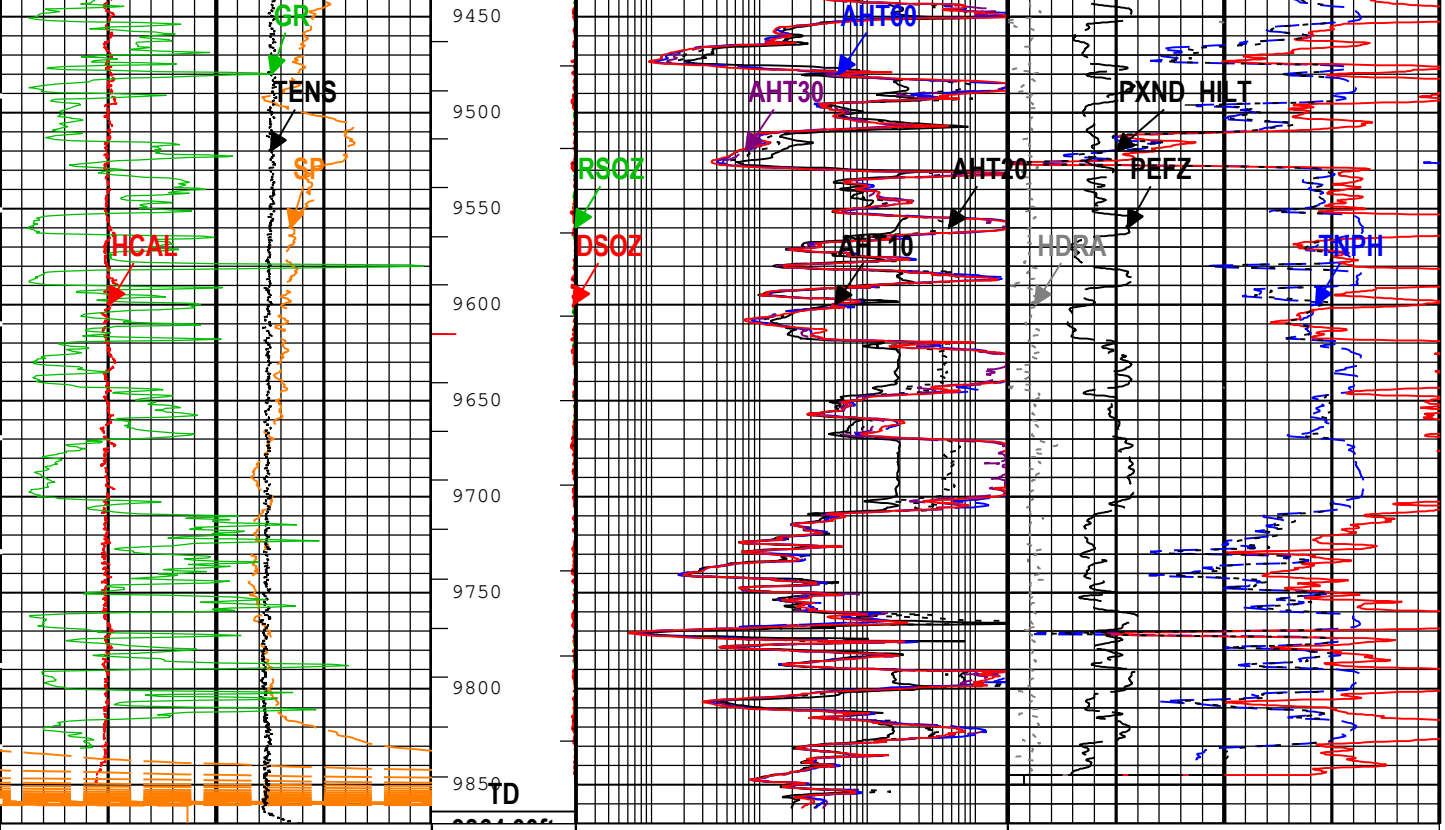


Caliper (HCAL) HDRS-H
6 in 16

Spontaneous Potential (SP) AIT-H
-80 mV 20

Cable Tension (TENS)
10000 lbf 0

Calibrated Gamma Ray (GR) HGNS-H
0 gAPI 150

Standard Resolution Density Standoff (DSOZ) HDRS-H
2.5 in 0

Resistivity Standoff Standard Resolution (RSOZ) HDRS-H
2.5 in 0

DSOA

RSOA

Array Induction Two Foot Resistivity A10 (AHT10) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A20 (AHT20) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A30 (AHT30) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A60 (AHT60) AIT-H
0.2 ohm.m 2000

Array Induction Two Foot Resistivity A90 (AHT90) AIT-H
0.2 ohm.m 2000

Thermal Neutron Porosity (Ratio Method) in Selected Lithology (TNPH) HGNS-H
0.3 ft3/ft3 -0.1

Standard Resolution Density Porosity (DPHZ) HDRS-H
0.3 ft3/ft3 -0.1

Crossplot Porosity for Neutron-Density (PXND_HILT)
0.3 ft3/ft3 -0.1

Density Standoff Correction (HDRA) HDRS-H
-0.05 g/cm3 0.45

Standard Resolution Formation Photoelectric Factor (PEFZ) HDRS-H
0 10

TIME_1900 - Time Marked every 60.00 (s)

IHV - Integrated Hole Volume every 10.00 (ft3)

ICV - Integrated Cement Volume every 100.00 (ft3)

ICV - Integrated Cement Volume every 10.00 (ft3)

IHV - Integrated Hole Volume every 100.00 (ft3)

Description: Triple Combo standard resolution template for Platform Express Format: Log ( TCOM 1in ) Index Scale: 1 in per 100 ft Index Unit: ft Index Type: Measured Depth Creation Date: 24-Feb-2023 02:44:40

**Additional Barberry I-1, Azalea I-1, Old Barberry I-1, Spirea I-1, and Cypress I-1 Permit Updates and Proposed Changes**

**Injection Well 130' Rathole Justification**

**Application for Underground Disposal of Water and Aquifer Exemption**

**Per WOGCC Rules & Regulations**

**Chapter 4, Sections 5 and 12**

**Class II Injection Wells**

**Samson Exploration**

#1889-2020

# APPLICATION FOR UNDERGROUND DISPOSAL OF WATER AND AQUIFER EXEMPTION PER WOGCC RULES & REGULATIONS CHAPTER 4, SECTIONS 5 AND 12

## Class II Injection Wells

## Samson Exploration, LLC

### Lasso SWD 21-1N
### Lasso SWD 21-2S

**Section 21, T15N, R65W**
**Laramie County, Wyoming**

**October 8, 2020**

RECEIVED
OCT - 9 2020
WYOMING OIL & GAS
CONSERVATION COMMISSION

Prepared By:
Petrotek
Petrotek Corporation
5935 South Zang Street, Suite 200
Littleton, Colorado 80127
Phone: (303) 290-9414
Fax: (303) 290-9580

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Table 3 – Proposed Casing Program

Table 4 – Surface Injection Pressure Calculations

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Table 6 – Radius of Emplaced Fluid Calculation

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Exhibit G-2 – Regional Stratigraphic Column

Exhibit G-3 – Cross Section Location Map

Exhibit G-4 – Structural Cross Section A-A'

Exhibit G-5 – Structural Cross Section B-B'

Exhibit G-6 – Structure Contour Map, Top of Lyons Sandstone

Exhibit E-1 – Proposed Wellbore Schematic, Lasso SWD 21-1N and 21-2N

### APPENDICES

Appendix A Regional Water Quality Data

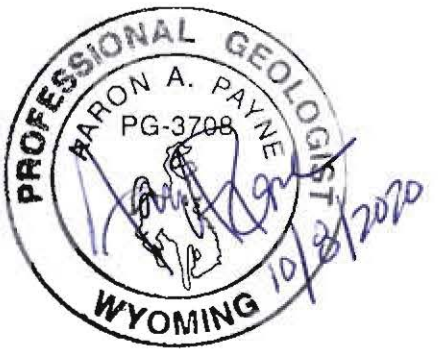
Appendix B Identified Source Wells and Available Water Quality Data

Appendix C Mineral, Working Interest, and Surface Owners within ½-Mile of Proposed Disposal Wells & Affidavit of Mailing

## STATEMENT OF CERTIFICATION

**Application for Underground Disposal of Water and Aquifer Exemption**
**Samson Exploration**
**October 2020**

### CERTIFICATION OF PROFESSIONAL GEOLOGIST:




Aaron Payne, Petrotek Corporation
Name of Professional Geologist

P.G. Number (Seal)

### CERTIFICATION OF PROFESSIONAL ENGINEER:




Ken Cooper, Petrotek Corporation
Name of Professional Engineer

P.E. Number (Seal)

## 1.0 Introduction

Samson Exploration, LLC (Samson), requests approval for the disposal of produced water from oilfield operations into the Entrada Formation and the Lyons through Fountain Formations via two proposed salt water disposal (SWD) wells. Injectate is to be primarily connate brines from wells operated by Samson that are producing from the Codell and Niobrara intervals. Total dissolved solids (TDS) concentrations of the proposed injection zone, based on offset well data, are projected to potentially exceed 10,000 mg/l. Confirmation of water quality at the proposed disposal well locations will be obtained upon drilling and testing. An aquifer exemption is requested for the proposed disposal well in the unlikely event that formation brine does not exceed 10,000 mg/l. Samson proposes the permitting of two SWDs, detailed below. These wells are to be co-located at the same surface facility and drilled directionally to the proposed injection zones to minimize surface disturbance while still maintaining horizontal separation between the wells at the completion depth.

**Lasso SWD 21-1N**

Surface Hole Location:

NW ¼ of NW 1/4, Section 21, T15N, R65W, Laramie County, Wyoming
Latitude/Longitude: 41. 25946, -104.67143 (NAD83)
596' FNL & 651' FWL

Bottom Hole Location:

NW ¼ of NW ¼, Section 21, T15N, R65W, Laramie County, Wyoming
Latitude/Longitude: 41.26089, -104.67142
75' FNL & 650' FWL

**Lasso SWD 21-2S**

Surface Hole Location:

NW ¼ of NW 1/4, Section 21, T15N, R65W, Laramie County, Wyoming
Latitude/Longitude: 41.25918, -104.67143 (NAD83)
696' FNL & 651' FWL

Bottom Hole Location:

SW ¼ of SW ¼, Section 21, T15N, R65W, Laramie County, Wyoming
Latitude/Longitude: 41.24924, -104.67136.
990' FSL & 700' FWL

These wells are proposed to be completed in the Entrada Sandstone via perforations and completed in the deeper Lyons through Fountain Formations via a slotted liner. Based on regional water quality of the targeted injection intervals from wells to the south located in northern Colorado, it is expected that both of the proposed intervals will potentially contain connate brine with salinity that exceeds 10,000 mg/L total dissolved solids (TDS). Confirmation sampling of water quality from the deeper Lyons through Fountain completion interval, and separately from the shallower Entrada completion interval, will be collected and provided to WOGCC during the drilling and completion activities.

The location of the two proposed wells are presented on Exhibit G-1. There are no existing disposal wells that are permitted for injection into the Entrada Formation or the Lyons through Fountain Formation in the northern portion of the Denver Basin in Wyoming. Permits have recently been filed for such wells but no public data exists documenting that any such wells have yet been drilled. The nearest wells that inject into these zones are located to the south in Colorado. Much of the information that has been provided in this application is based on offset injectors located to the south in the northern Denver Basin where the "DJ Injection Zone" (i.e., Lyons through Fountain Formation) is utilized for disposal of oilfield produced waters.

The two proposed wells will be drilled directionally. The Lasso SWD 21-1N well will be drilled approximately 500 feet to the north of the surface hole location and the 21-2S well will be drilled approximately 3,600 feet to the south of the surface hole location.

This document is organized as two sections. Section 2 presents justification for an aquifer exemption per Chapter 4, Section 12 of the applicable WOGCC rules, if required. Section 3 of this document presents justification for disposal of water per Chapter 4, Section 5, of the applicable WOGCC rules.

## 2.0 Application for Aquifer Exemption, Chapter 4, Section 12

For the two proposed disposal wells, a ¼-mile radius ellipse with respect to the surface hole and bottom hole locations for both wells is requested as the area of the exempted aquifer, if required. Exhibit G-1 shows the outline of the ¼-mile radius around the well.

### *2.1 Chapter 4, Section 12(a)(i)*

**It is mineral, hydrocarbon, or geothermal energy producing.**

Based on WOGCC records, there is no oil or gas production in the Wyoming portion of the Denver Basin in the Entrada Sandstone, and very minor production in the Lyons through Fountain Formations. Minimal production (501 bbls and 207 MCF) was reported from a well approximately 18 miles to the west in Section 29, T15N, R62W (Champlin Amoco 318 B 1; API No. 21-20231). The nearest documented production from the Lyons Sandstone are from fields in northern Colorado in Larimer and Weld Counties, approximately 10 to 20 miles south of the Wyoming border (Higley and Cox, 2007).

### *2.2 Chapter 4, Section 12(a)(ii)*

**It is situated at a depth or location which makes recovery of fresh or potable water economically or technologically impractical.**

The proposed Entrada Sandstone and Lyons through Fountain Formation injection intervals are both at a depth and location that makes the recovery of potable water impractical. A stratigraphic column of the Denver Basin is provided as Exhibit G-2.

Formation depths for relevant formations are included below in Table 1. At these depths, potable water would not be economically or technologically practical.

**Table 1. Projected Formation Depths near Lasso SWD Wells**

| Formation | Top (TVD; ft) | Comment |
|---|---|---|
| Fox Hills | 1,560' | Lowermost USDW |
| Pierre Shale | 1,900' | |
| Niobrara | 8,380' | |
| Codell | 8,680' | Deepest penetrated formation within ½-mile |
| Muddy | 9,300' | |
| Morrison | 9,630' | Overlying Confinement for Entrada |
| Entrada | 9,830' | *Proposed Injection Zone* |
| Lykins | 9,910' | Confining Layer |
| Blaine Anhydrite | 10,550' | Confining Layer |
| Lyons Sandstone | 10,590' | *Proposed Injection Zone;* Completed to ~12,000 ft BGL via 4 ½" slotted liner |
| Satanka | 10,660' | |
| Ingleside | 10,880' | |
| Fountain | 11,000' | |

The nearest population center to the proposed disposal wells is Cheyenne, WY, which is located approximately 7 miles to the southwest. It is highly unlikely that the Entrada Sandstone or the deeper Lyons/Fountain interval would be used to supply water due to the highly mineralized formation waters because substantial water treatment would be required, and since shallow supplies of better-quality water are available locally. It is anticipated that TDS values of the injection formations will potentially be in the range of approximately 10,000 mg/L or greater, which is detailed in the subsequent section.

### *2.3 Chapter 4, Section 12(a)(iii)*

**It is so contaminated that it would be economically or technologically impractical to render the water fit for use as fresh and potable water.**

The Entrada Sandstone and the Lyons through Fountain Formation intervals are relatively deep (>10,000 feet) and are projected to contain fluids with naturally occurring relatively high concentrations of TDS which renders these formation waters uneconomical and technologically impractical to treat for use as potable water. These formation waters may also contain detectable levels of naturally occurring hydrocarbons.

Regional water quality data for the Entrada and the Lyons through Fountain Formation are limited in the northern portion of the Denver Basin, particularly in southeastern Wyoming. A review of WOGCC water quality data and from the USGS Produced Waters Database did not identify water quality data in the vicinity for the proposed injection zones.

Total dissolved solids (TDS) concentrations have been compiled for multiple Class II UIC wells in Weld County in northern Colorado that have groundwater quality data for these

formations. Appendix A presents a summary of information compiled from more than 40 injection wells that are completed to the Entrada and the DJ Injection Zone (Lyons through Fountain Formation) in the Denver Basin in northern Colorado. Note that the "DJ Injection Zone" (interval from the Lyons Sandstone through the Fountain Formation) is a common designation used by the Colorado Oil and Gas Conservation Commission (COGCC). The COGCC considers the entire interval of the Lyons through Fountain to be a single injection zone that is utilized for injection in dozens of disposal wells in northern Colorado.

TDS concentrations from the Entrada Sandstone from the 11 samples reported in Appendix A are all in excess of 10,000 mg/L. These data range from 10,490 mg/L to greater than 30,000 mg/L TDS. Water quality calculations conducted at the Childers 13-7 well (API No. 21-20402; Section 7 T12N, R65W, located approximately 15 miles south of the proposed Samson injection wells yield an estimated water quality of 11,000 to 12,000 ppm as NaCl. Based on these data, the groundwater in the Entrada Sandstone at the proposed location of the Samson wells is likely in excess of 10,000 mg/L TDS.

TDS concentrations are also reported for the DJ Injection Zone for more than 40 wells in northern Weld County, Colorado. These data are also included in Appendix A. Data indicate that TDS concentrations in the DJ Injection Zone are consistently above 10,000 mg/L, and are reported to be as high as 30,000 to greater than 100,000 mg/L. Note that there are isolated samples collected that are less than 10,000 mg/L. The most likely explanation for these data points is insufficient swabbing/purging prior to sampling and that these samples included some component of mud filtrate.

Based on these data, the proposed injection zones to be completed in the Samson proposed disposal wells can be projected to contain fluids with TDS concentrations in excess of 10,000 mg/L.

Samson will collect water samples from the proposed disposal wells to demonstrate water quality. Representative fluid samples will be collected in the Entrada Sandstone, which will be completed via perforations in the long string casing. In addition, at a minimum a co-mingled fluid sample will be collected from the deeper completion interval from the Lyons through Fountain Formations. This deeper injection zone will be completed by installing a slotted liner across this entire interval. In addition to a standard water analysis, Samson will test the water for Oil and Grease, Total Petroleum Hydrocarbons, Diesel-Range Organics (DRO), Gasoline-Range Organics (GRO), and Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX).

### *2.4 Chapter 4, Section 12(a)(iv)*

**It is located over a mining area subject to subsidence or catastrophic collapse.**

This portion of Chapter 4 is not applicable; the proposed disposal well is not located in a mining or subsidence area.

### *2.5 Chapter 4, Section 12(a)(v)*

**It has a total dissolved solids (TDS) of more than five thousand (5,000) and less than ten thousand milligrams per liter (10,000 mg/l) and is not reasonably expected to be used as fresh or potable water.**

Based on available records summarized in Section 2.3 of this document and provided in Appendix A, the TDS concentrations of the Entrada Sandstone and the Lyons through Fountain Formation intervals will contain fluids with a TDS concentration in excess of 5,000 mg/l are that are likely to be in excess of 10,000 mg/L.

Samson will collect water samples from the proposed disposal wells to demonstrate water quality. Representative fluid samples will be collected in the Entrada Sandstone, which will be completed via perforations in the long string casing. In addition, at a minimum a co-mingled fluid sample will be collected from the deeper completion interval from the Lyons through Fountain Formations. This deeper injection zone will be completed by installing a slotted liner across this entire interval. In addition to a standard water analysis, Samson will test the water for Oil and Grease, Total Petroleum Hydrocarbons, Diesel-Range Organics (DRO), Gasoline-Range Organics (GRO), and Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX).

If water quality as TDS is confirmed to be in excess of 10,000 mg/L, an aquifer exemption is not required. None of the connate fluids can reasonably be expected to be used as fresh or potable water.

### *2.6 Chapter 4, Section 12(b)*

**Interested parties wishing to have an aquifer exempted must submit to the Commission an application which includes sufficient data to justify the proposal. At a minimum a structure or isopach map, geologic description, and legal description of the area to be exempt needs to be filed. The Commission will provide thirty (30) days legal notice to a public hearing on the matter.**

#### Regional Geology

The proposed wells are located in the northern portion of the Denver Basin. North of the Greeley Arch, this area of the Denver Basin is also referred to as the Cheyenne Basin. The Denver Basin is a broad, oval, asymmetric structural basin approximately 300 miles long from north to south and approximately 170 miles wide from west to east. The basin axis lies near the western edge of the basin, and the basin is bounded in this portion of Wyoming by the Hartville Uplift to the north, and the Laramie and Front Range to the west. On the western side, sediments dip steeply to the east against uplift areas; on the east side of the basin in Nebraska and Kansas, strata dip gently to the west.

This basin is filled with sediments of marine and continental origin ranging in age from early Paleozoic through the Cenozoic. Total sedimentary thickness in this portion of the Denver Basin is estimated at approximately 12,500 feet to Precambrian basement rocks.

**Structure**

The proposed disposal wells are located in the interior portions of the Denver Basin, where there is minimal observed structure from the Precambrian basement to the surface. The primary structural features in the basin are observed near the basin margins, distant from the proposed wells. There are documented basement rooted faults in the Silo Field, located approximately 10 miles north of the proposed wells. Based on proprietary seismic data reviewed by Samson near the proposed wells, there are only minor structural features observed from these data, with minimal vertical offset in relation to the confining zones present between the proposed injection zones.

**Stratigraphy**

The surface bedrock in the vicinity of the proposed disposal wells is the Ogallala Formation. Estimated formation depths were provided in Table 1 in Section 2.2, and a regional stratigraphic column is provided as Exhibit G-2. As there is limited well control below the Cretaceous section, regional cross sections were constructed based on wells that penetrate to the Lyons Sandstone to characterize the proposed injection zones. Exhibit G-3 presents the cross-section location map, and the north-south cross-section A-A' is presented on Exhibit G-4, and the east-west cross-section is shown on Exhibit G-5. A structural contour map to the top of the Lyons Sandstone, based on regionally available data and wireline logs, is presented on Exhibit G-6.

**Disposal Zones**

***Entrada Sandstone***

The Entrada Sandstone or Entrada Formation unconformably overlies Triassic-age sediments (Lykins Formation) and is early Jurassic in age. Overlying the Entrada is the Morrison Formation. Based on limited regional wireline logs, the gross thickness of the Entrada is approximately 70 to 80 feet. Near the proposed wells, the top of the Entrada is estimated at approximately 9,830 ft BGL and the base at approximately 9,900 ft BGL. A net thickness of porous sandstone (>10% porosity) is estimated at 50 feet, with average porosity in this interval of approximately 18%. In some well records, this formation is described as the Sundance Formation.

***Lyons Through Fountain Formation***

The Lyons through Fountain Formation is proposed as the deeper injection interval for the proposed wells. This stratigraphic interval is referred to as the DJ Injection Zone by the Colorado Oil and Gas Conservation Commission. The slotted liner completion has

been selected to increase the likelihood that the well will communicate to more potential effective injection zone thickness. Cemented and perforated casing across the DJ injection zone runs the risk of bypassing significant injectivity since not all intervals that take fluid can be easily correlated based solely on wireline logging data. It is apparent that in many of the Class I and Class II wells in the Colorado portion of the DJ Basin, primary porosity data does not always define those zones that accept fluid, and the injectivity that is observed is due to some level of naturally occurring secondary porosity and/or fracturing that is present in this interval.

The proposed Lyons through Fountain Formation injection is estimated to be approximately 1,400 feet thick. The proposed slotted liner completion will allow communication with a large thickness of sediments. For the purposes of this application, the total net thickness of this zone is estimated at approximately 300 feet, and average porosity in these intervals is estimated to be approximately 10-12%.

Fountain Formation

In the northern Denver Basin, there has been a combination of terminology and nomenclature used for Pennsylvanian and Permian units. The Desmoinesian through Wolfcampian interval is time equivalent to the Minnelusa Formation in the Powder River Basin, the Fountain Formation along the Front Range, and the Casper and Hartville Formations to the west and north, respectively. To the south and east, mid-continent terminology utilizing chronostratigraphic series is used for late Paleozoic strata. In this application, the entire Pennsylvanian-age sediments from Wolfcamp through Desmoines is referred to as the Fountain Formation (Garfield et al., 1988).

The Fountain Formation consists of arkosic fanglomerates eroded from the early Pennsylvanian Ancestral Rocky Mountain Uplift to the west that was deposited to a shallow carbonate ramp to the east. Sands were confined to an area near the uplift, and carbonate deposition occurred further offshore.

To the south of the proposed wells, fanglomerates of the Upper Fountain Formation are replaced by marine carbonates and sandstones of the Ingleside Formation north of Boulder, Colorado. The Ingleside thickens to the north along the Front Range and is similar in lithology to the upper Paleozoic carbonate section in the northern Denver Basin.

Pennsylvanian and Permian rocks in the Powder River Basin to the north comprise the Minnelusa Formation, where the Upper Minnelusa (Wolfcampian) contains interbedded dolomites and eolian sands. The Middle Minnelusa (Leo Member, Desmoinesian-Virgillian) is dominated by carbonates with some interbedded clastics and thin shales. Anhydrite is also common in the Minnelusa in the southern Powder River Basin.

The Desmoinesian, Missourian, Virgillian, and Wolfcampian series in the mid-continent are comprised of mixed carbonate/siliciclastic cyclothem sequences and has been subdivided into groups, formations and members (Garfield et al., 1988).

In the northwest portion of the Denver Basin, the rocks are more similar to the Ingleside and Minnelusa Formations. The regressive clastic component of Missourian type cyclothems is absent from most Pennsylvanian facies successions in this area making correlation of Mid-Continent divisions difficult (Garfield et al., 1988).

With the exception of salt deposits in the Wolfcampian in the northern Denver Basin, most of the Desmoinesian through Wolfcampian deposits can be correlated to the Powder River Basin, suggesting that during much of the Pennsylvanian and early Permian, the northern Denver Basin and Powder River Basin were connected by a late Paleozoic seaway, termed the Lusk Embayment. The record of Pennsylvanian-Permian sediments reflects short term rise and fall of sea level superimposed on an overall lowering of relative mean sea level from Desmoines through Wolfcampian time.

Ingleside Formation

The lowermost Permian unit in the region is the Ingleside Formation which unconformably overlies the Fountain Formation. It is composed of fine- to medium-grained feldspathic sandstones and ranges in thickness from 100 to 330 feet in the region. Data shows that the Ingleside increases in thickness to the east and carbonate content increases towards the center of the basin. The depositional environment is mostly fluvial near the Front Range and becoming shallow marine to the east (Sonnenberg, 1981).

Satanka Formation

The Satanka Formation (also called the Owl Canyon Formation) unconformably overlies the Ingleside. It is composed of red and gray sandstones, red siltstones, and red mudstones. The mudstones become more dominant toward the center of the basin. Thickness also increases to the east, ranging from 100 to 245 feet. The original transport probably occurred via fluvial systems followed by lacustrine deposition (Berman, 1978).

Lyons Sandstone

The late Permian Lyons Sandstone overlies the Satanka. The thickness of the Lyons ranges from 20 to 200 feet in the general vicinity of the northern Denver Basin. It is typically deep red to pink to white depending on hydrocarbon concentration (Levandowski et al, 1973). Throughout most of the region it is a fine-grained, well sorted sandstone that formed as a near-shore deposit. Weimer and Land (1972) interpret the depositional environment as being fluvial and eolian and attribute the variance in thickness to the recurrent movement of basement fault blocks.

**Confining Zones**

The lower confining zone for the Lyons through Fountain Formation is the underlying Precambrian basement, though Samson does not intend to complete the proposed wells

entirely through the Fountain Formation to basement. Overlying the deeper injection interval is the Blaine Anhydrite, which is estimated to occur at approximately 10,550 ft BGL and is approximately 40 feet thick. Overlying the Blaine is the Triassic-age Lykins Formation, which is approximately 600 feet thick and consists of sandstones, siltstones, mudstones, and carbonates. This formation is relatively impermeable and will provide overlying additional overlying confinement.

The uppermost Entrada injection zone is confined by the underlying Lykins Formation and by the overlying low permeability fine-grained sediments of the Morrison Formation. The Morrison is approximately 200 feet thick and is predominantly a shale/mudstone and siltstone with ratty and thin sandstone intervals.

## USDW

To determine the current use of water in the area, a water rights search of the Wyoming State Engineers Office (SEO) website for the nine sections surrounding the proposed disposal wells was conducted to assess nearby groundwater wells. A table summarizing these wells is provided as Table 2. There are 9 wells that have been identified in this area. Total depths of these wells range from 60 to 420 feet. All of these wells are listed as completed in the SEO records for stock use. Based on these depths, these stock wells are likely completed in the surficial geologic unit, the Ogallala Formation, the Arikaree Formation, or the lowermost White River Formation. These three formations comprise the regional Tertiary Aquifer, which is the primary source of groundwater in the region.

**Table 2. SEO Groundwater Wells**

| WR Number | Priority Date | WR Status | Company/Owner | Facility Name | Use | Twn | Rng | Sec | Qtr-Qtr | Total Flow (GPM) | TD (Ft) | SWL (Ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P149028.0W | 01/31/2003 | Cancelled | WARREN LIVESTOCK LLC | GRAVEL PIT WELL | STK | 15N | 65W | 15 | SWSE | 25 | - | - |
| P8797.0P | 09/21/1900 | Complete | JHD Ranch, LLC | #19 MIDDLE CP MILL | STK | 15N | 65W | 15 | NWNW | 5 | 60 | 40 |
| P130733.0W | 11/13/2000 | Complete | JHD RANCH LLC | HILLSIDE | STK | 15N | 65W | 17 | NESE | 0 | 180 | 50 |
| P18618.0P | 08/31/1920 | Complete | MORSE FAMILY TRUST | M. L. BRINEY NO. 1 | STK | 15N | 65W | 20 | SWSW | 4 | 300 | 154 |
| P18619.0P | 12/31/1922 | Complete | MORSE FAMILY TRUST | FRED BRINEY #1 | STK | 15N | 65W | 22 | SWSE | 3.5 | 205 | 167 |
| P18620.0P | 12/31/1914 | Complete | MORSE FAMILY TRUST | JOHN BRINEY #1 | STK | 15N | 65W | 22 | NWSW | 3.5 | 220 | 180 |
| P212662.0W | 06/24/2020 | Incomplete | MARK E. CHILD | MEC NO 22 | STK | 15N | 65W | 22 | NWSW | 25 | - | - |
| P18621.0P | 09/21/1910 | Complete | MORSE FAMILY TRUST | PAUL LONG #1 | DOM_GW; STK | 15N | 65W | 28 | SWNW | 4 | 420 | 191 |
| P4178.0P | 07/31/1911 | Complete | WAYNE L. CHILD | MARPLE #1 | STK | 15N | 65W | 28 | NWSW | 7.5 | 260 | 196 |

* Source: http://seoweb.wyo.gov; accessed 9/17/2020

## Lowermost USDW

The lowermost aquifer above the Pierre Shale is the Fox Hills Sandstone that occurs at a depth of approximately 1,600 feet. The Pierre Shale is a regional confining unit in the Denver Basin. While identified groundwater usage in this area of the basin is exclusively from the overlying Tertiary Aquifer, the water in the underlying Fox Hills is likely relatively fresh (<3,000 mg/L TDS), and thus this interval is identified as the lowermost USDW. Water quality data from the Fox Hills in this portion of the basin was not available.

## Area Seismicity

There are no faults identified within the vicinity of the Project location. The proposed wells are located within Seismic Zone 1 according to the 1997 Uniform Building Code (UBC) Seismic Zone Map where effective peak accelerations (90% chance of non-exceedance in 50 years) can range from 5%-10%g. Based on the 2,500-year probabilistic acceleration map, which is defined as a 2% probability of exceedance in 50 years, from the most recent USGS Seismic Hazard Map (USGS, 2014), the wells are located in an area where the estimated peak horizontal acceleration ranges from approximately 6% to 10%g.

The first earthquake recorded in Laramie County occurred in 1927, an intensity II event centered approximately 5 miles north of Cheyenne. The USGS recorded a very small earthquake approximately 10 miles west-southwest of Cheyenne in 1967. No magnitude or intensity was associated with this event. There are also several regional earthquakes documented generally to the west in Albany County near Laramie (Case et al., 2002). In general, the proposed wells are located in an area of relatively minor seismic activity.

## References

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Case, J.C., R. Kirkwood, and Toner, R.N., 2002, Basic Seismological Characterization for Laramie County, Wyoming, Wyoming State Geological Survey, 14 p., (http://www.wrds.uwyo.edu/wrds/wsgs/hazards/quakes/seischar/Laramie.pdf)

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Weimer, R.J., and Land, C.B., 1972. Lyons Formation (Permian), Jefferson County, Colorado: A Fluvial Deposit: The Mountain Geologist, Vol. 9, Nos. 2-3, pp. 289-297.

## 3.0 Application for Authorization to Dispose, Chapter 4, Section 5

### *3.1 Chapter 4, Section 5(a)*

**The underground disposal of fresh water or of salt water, brackish water, or other water unfit for domestic, livestock, irrigation, or other general uses, is permitted only upon order of the Commission or approval of the Supervisor, obtained pursuant to an application therefore filed in accordance with Chapter 5, Rules of Practice and Procedure, as amended herein. Order authorizing disposal wells shall remain valid unless revoked by the Commission or just cause. In addition, there is assessed a seventy-five dollar ($75.00) annual fee on all new and old disposal wells.**

A check for the amount of $250 is attached for the required application fee.

### *3.2 Chapter 4, Section 5(b)*

**Disposal Well Permits. The applicant shall demonstrate by compliance with Chapter 3, Section 22 of these rules that the proposed disposal operation will not endanger fresh water sources. Disposal wells shall be cased and the casing cemented in such a manner that damage will not be caused to oil, gas, or fresh water sources.**

Exhibit E-1 presents the proposed disposal wellbore schematics for the Lasso SWD 21-1N and Lasso SWD 21-2S Class II UIC disposal wells.

The following provides a summary of the proposed construction procedures for the two proposed wells.

1. Upon preparation of the site and mobilization of required equipment, 20" conductor casing will be driven to approximately 100 feet below ground level (ft BGL). If driven casing is not practical due to equipment availability or other factors, 20" conductor casing will be cemented to surface in a 24" borehole to an anticipated depth of approximately 100 ft BGL. If a gauge borehole diameter is assumed and 25% excess cement is assumed, approximately 100 sx of 1.2 $ft^3$/sx yield of Class A cement with additives or suitable equivalent would be utilized to cement the string to surface. Site specific conditions will be used to further refine the cement volume.
2. A 14 ¾" borehole will then be drilled out to a depth of approximately 3,600 ft BGL. The hole will be conditioned and 10 ¾", 51 lb/ft, N-80 ST&C (or suitable equivalent) casing will be installed from surface to a depth of approximately 3,600 ft BGL. The cementing program will be determined based on field conditions, but a minimum of 2,953 sx of 1.2 $ft^3$/sx of Class A standard cement (assuming excess) with additives, or a suitable equivalent will be pumped. A minimum of 75% excess based on open hole volume will be utilized and may be adjusted based on measured hole conditions. It is anticipated that a float shoe will be used with a float

collar located one joint off bottom, and that centralizers will be placed at a minimum of one every third joint depending on hole conditions.

3. After the surface casing string has been cemented and a minimum of 36 hours waiting on cement (WOC) time has elapsed, a cement bond log will be conducted over the casing interval to demonstrate cement integrity of the surface casing string cement. Thereafter, remaining cement will be drilled out of the casing shoe and a 9 1/2" hole will then be drilled to a depth of approximately 10,580 ft BGL, approximately 30 feet into the Blaine Anhydrite. Openhole logging will be completed from the base of the surface casing to approximately 10,580 ft BGL.
4. After the logging/testing program is completed, the hole will be conditioned and 7 5/8", 39 lb/ft, P110 LT&C casing (or suitable equivalent) will be installed from surface to a depth of approximately 10,580 ft BGL. The cementing program will be determined based on field conditions, but at a minimum will consist of Class A standard cement with additives or suitable equivalent. At least 1,910 sacks of cement, assuming excess, will be pumped assuming a yield of 1.2 $ft^3$/sx. Lightweight cement with a higher yield may be pumped depending on well conditions and availability. Excess cement (minimum of 25% of the calculated open hole volume) will be utilized and may be adjusted based on measured hole conditions. It is anticipated that a float shoe will be used with a float collar located one joint off bottom, and that centralizers will be placed at a minimum of one every third joint depending on hole condition. Depending on hole conditions and geologic considerations, a two-stage cement job utilizing a DV tool and ECP set at a depth of approximately 7,500' may be utilized in conjunction with or in place of light-weight cement.
5. After the 7 5/8" casing string has been cemented and a minimum of 36 hours waiting on cement (WOC) time has elapsed, a cement bond log will be conducted over the 7 5/8" casing interval to demonstrate cement integrity behind casing. If cement returns to surface are observed, a cement bond log may not be conducted based on well conditions, schedule, and equipment availability.
6. Thereafter, the well will be deepened through the DJ injection zone using a 6 1/8" bit with a target TD near the base of the Fountain at approximately 12,000 ft BGL. Logging while drilling (LWD) will be run to collect gamma ray and resistivity during drilling. After drilling is completed, attempt openhole logging from TD to the long-string casing shoe.
7. A 4 ½" custom slotted liner will then be run from approximately 10,480 ft BGL to TD and set on a liner hanger in the long-string. If open hole logs are not feasible during drilling operations, run cased-hole neutron porosity log through liner.

The following table provides a summary of the proposed casing program.

**Table 3. Proposed Casing Program**

| Casing and Hole Size | Casing Specifications | Depths (TVD) | Comments |
|---|---|---|---|
| 20" Conductor (24" Borehole) | | 0 – 100 ft | Driven; if not practical will be cemented to surface. |
| 10 ¾" Surface (14 ¾" Borehole) | 51 lb/ft, N-80, ST&C | 0 – 3,600 ft | New casing, cemented to surface. |
| 7 5/8" Long-string (9 1/2" Borehole) | 39 lb/ft, P-110, LT&C | 0 – 10,580 ft | New casing, cemented to surface |
| 4 ½" Slotted Liner (6 1/8" Borehole) | 11.6 lb/ft, L-80, LT&C | 10,480 – 12,000 ft | End of liner at ~12,000 ft in 6 1/8" openhole |

As required, a mechanical integrity test required by WOGCC will be performed upon completion. Samson proposes to pressure test the casing-tubing annulus to 1,000 psi, or the maximum permitted injection pressure, whichever is lower. WOGCC will be notified prior to the testing, and documentation will be provided to WOGCC.

### *3.3 Chapter 4, Section 5(c)(i)*

**A plat showing the location of the disposal well or wells, including abandoned and drilling wells and dry holes, and the names of all lease Operators or Owners and surface owners within a one-half (1/2) mile radius from the proposed disposal well or wells.**

Exhibit G-1 shows the location of the proposed disposal wells. There are no disposal wells that are completed in the proposed injection zones in the area of review. The nearest wells completed to either the Entrada or the Lyons through Fountain Formations are located to the south in northern Colorado, where the Lyons through Fountain interval is commonly referred to as the DJ Injection Zone. The nearest well that was drilled to the proposed injection zones is located approximately four miles to the west. This well (Warren Livestock 11-1, API No. 21-05091, Section 11, T15N, R66W) was drilled to a total depth of 11,880 feet, approximately 100 feet into the Lyons Formation.

Exhibit G-1 also shows the locations of oil and gas wells within a ½-mile ellipse that surrounds the surface hole and bottomhole locations of the proposed wells. There is only one well within this area, and this well does not penetrate the overlying confining zone. This well was drilled to the Codell Sand. Note that there are also two proposed SWD wells to the west within the ½-mile ellipse (Lasso SWD 17-1N and Lasso SWD 17-2S; surface locations in the SE ¼ of the SE ¼ of Section 17). These permits have also been submitted by Samson; the permit application for these wells (same proposed injection zones) is pending and these wells have yet to be drilled.

Appendix C, attached to the Application, provides a summary of information regarding all lease operators or owners and surface owners within this ½-mile radius.

### *3.4 Chapter 4, Section 5(c)(ii)*

**An affidavit showing that said lease Operators or Owners and surface owners within a one-half (1/2) mile radius have been provided a copy of the application for disposal.**

An affidavit of mailing stating that all surface owners and working interest owners as listed in Appendix C have been mailed a copy of the application has been provided with this application.

### *3.5 Chapter 4, Section 5(c)(iii)*

**The names, description, and depth of the formation into which water is to be injected, including a mechanical log of the proposed disposal well or wells if one is available.**

Samson plans to dispose of produced water into the Entrada Sandstone and the interval from the Lyons Sandstone through the Fountain Formation. Descriptions and depths of these formations and proposed perforation depths for the Entrada and the slotted liner completion for the Lyons/Fountain were described in Section 2.6 of this application. The proposed wellbore schematic of these wells is provided as Exhibit E-1.

Therefore, construction details, logs, and mechanical integrity data will be provided per WOGCC regulatory requirements upon well completion.

### *3.6 Chapter 4, Section 5(c)(iv)*

**A description of the casing in the disposal well or wells, or the proposed casing program and the proposed method for testing casing before use of the disposal well or wells.**

See Section 3.2, Response regarding Chapter 4, Section 5(b)

### *3.7 Chapter 4, Section 5(c)(v)*

**A statement specifying the source of water to be injected.**

The source of water to be disposed into the proposed disposal well will be produced and fracture stimulation flowback water from the Codell Sandstone and Niobrara Formation generated by Samson. Potential source wells that will initially utilize the facility are provided in Appendix B. Produced water from future development may also be disposed. Any future wells will be sampled, and analyses will be submitted to the WOGCC.

### *3.8 Chapter 4, Section 5(c)(vi)*

**The estimated minimum and maximum amount of water to be injected daily.**

The estimated minimum and maximum water volumes to be injected into the proposed disposal wells are between 0 barrels and 10,000 barrels per well, per day, respectively. In the event that larger daily injection rates are required, WOGCC will be notified. It is noted that similar completions in northern Colorado to the DJ Injection Zone (Class I and Class II wells) consistently achieve long-term injection rates of 200 to 400 gpm (6,857 to 13,714 barrels per day).

### *3.9 Chapter 4, Section 5(c)(vii)*

**The average and maximum disposal pressure.**

Because there is limited to no regional data regarding fracture pressure in these formations in this portion of Wyoming, a fracture gradient of 0.60 psi/ft is assumed at the top of the proposed injection zones. This value is used by the Colorado Oil and Gas Conservation Commission for the DJ Injection Zone (equivalent to the Lyons/Fountain interval) in the absence of site-specific data.

Based on this estimated fracture gradient of 0.60 psi/ft for the two proposed Lasso SWD wells, a temporary maximum requested surface injection pressure is calculated in Table 4 below:

**Table 4. Surface Injection Pressure Calculations**

| | |
|---|---|
| Depth to top Perforation (Entrada) | 9,830 ft |
| Fracture Gradient | 0.60 psi/ft |
| Fracture Pressure at Top of Formation<br>(0.60 psi/ft * 9,830 ft) | 5,898 psi |
| Fluid Gradient | 0.433 psi/ft |
| Fracture Pressure at Surface<br>(0.60 psi/ft – 0.433 psi/ft) * 9,830 ft | 1,642 psi |

The above fracture pressure calculation does not incorporate the effects of any tubing frictional loss that would occur during injection. Samson requests a temporary maximum surface injection pressure of 1,642 psi. A step-rate test will be performed in both the Entrada and the Lyons/Fountain intervals after the first well is drilled and will provide those results to the WOGCC. Average injection pressure is anticipated to be dependent on well condition and flow rate and will maintained at a value that is less than permitted maximum pressure.

### *3.10 Chapter 4, Section 5(c)(viii)*

**Evidence and data to support a Commission finding that the proposed disposal well will not initiate fractures through the overlying strata or confining zone which could enable the injection fluid or formation fluid to enter the fresh water strata.**

Testing will be performed to ensure that operating injection pressures remain below pressures that could initiate fractures through the overlying strata or confining zone. See Section 3.9 of this document response to Chapter 4, Section 5(c)(vii) requirements for the temporary pressure requested. The Entrada and the Lyons/Fountain injection zones will be subjected to a step-rate test, and to supplement such testing an injectivity test with a temperature survey may be conducted to demonstrate that injection will not result in fluids migrating out of the proposed disposal zone.

### *3.11 Chapter 4, Section 5(c)(ix)*

**Standard laboratory analysis of the water to be disposed and the water in the formation into which disposal is taking place. The method of water analysis is subject to review by the commission or Supervisor. Water Analysis Report (Form 17) illustrates the minimum parameters for which water must be analyzed. Other reporting formats which include this minimum information may be accepted.**

As discussed in Section 3.7 of this document as a response to Chapter 4, Section 5(c)(v) requirements, the source of water to be disposed will be produced and fracture flowback water from the Codell Sandstone and Niobrara Formation. Potential source wells, including available water quality data, for these disposal wells are provided in Appendix B.

The formations into which disposal will occur will include the Entrada Sandstone and a deeper interval that includes the Lyons Sandstone through the Fountain Formation. Based on regional water quality provided in Appendix A, TDS concentrations can be projected that exceed 10,000 mg/L. Water quality samples will be collected to be analyzed for TDS and major ions, as well as Oil and Grease, Total Petroleum Hydrocarbons, DRO, GRO, and BTEX to determine the presence of naturally occurring hydrocarbons in the proposed disposal formation(s).

### *3.12 Chapter 4, Section 5(c)(x)*

**A reference to the Commission order exempting the aquifer that is to receive the injected fluid.**

This document (see Section 2) concurrently provides the relevant request for an aquifer exemption, if required. Due to available regional water quality data indicating that the Entrada Sandstone and Lyons/Fountain (referred to as the DJ Injection Zone in northern Colorado where data is available), these intervals are expected to have water quality as

TDS in excess of 10,000 mg/l, and therefore an aquifer exemption may not be necessary for the proposed disposal well. Samples of injection formation brine will be obtained by Samson during well installation and completion to confirm the salinity of the two injection zones.

### *3.13 Chapter 4, Section 5(c)(xi)*

**The applicant shall provide for a one-quarter (1/4) mile radius of investigation for mechanical conditions of all wells which have penetrated the disposal zone surrounding a proposed disposal well. Specifically known and documented geological features may limit the need to review all wells within the one-quarter (1/4) mile radius.**

There are no wells located within a ¼-mile radius of the surface hole or the bottomhole locations for either of the proposed wells. There is one well located within a ½-mile radius of the proposed disposal wells, which is summarized in Table 5 and shown on Figure G-1. This well is a horizontal producing oil well completed in the Codell Sand and operated by Samson Exploration, LLC, and was not drilled deep enough to penetrate the overlying confining zone.

**Table 5. Wells Located within ½-Mile of the Proposed Wells**

| API No. | Well Name | Total Depth (ft) | Bottom Formation | Status |
|---|---|---|---|---|
| 2121129 | Elmo 21-16-14-1CH | 8,688 | Codell Sand | PO |

* Source: wogcc.state.wy.us

A Radius of Emplaced Fluid calculation is presented in Table 6 based on a continuous average injection rate of 7,000 bbls/day for a period of 15 years. The estimated net thickness is based on an estimated 50 feet of porous sand (>10% porosity) in the Entrada, which is approximately two-thirds of the gross thickness of this interval (estimated at approximately 75 feet). For the Lyons through Fountain interval, which has a gross thickness of approximately 1,400 feet, a conservative estimate of 300 feet of net thickness is estimated to potentially accept fluid via injection. This total net thickness represents less than 25% of the estimated gross thickness of these two injection zones. Average porosity based on local well logs for these intervals is estimated to be 12% for the net thickness interval. As shown in the following table, the radius of emplaced fluid is estimated to be 0.242 miles, or 1,277 feet, which is smaller than the statutory minimum AOR of ¼ mile (1,320 feet).

Where:

$$\text{Radius of Emplaced Fluid} = (Qt/\pi Hp)^{1/2}$$

**Table 6. Radius of Emplaced Fluid Calculation**

| | |
|---|---|
| Receiver Net Thickness (H, Assumed as Perf Thickness) | 350 ft |
| Injection Period | 15 years |
| Injection Period (t) | 5,475 days |
| Injection Rate | 7,000 bwpd |
| Injection Rate (Q), 7,000 bwpd | 39,305 $ft^3$/day |
| Porosity (p) | 0.12 |
| Radius of Emplaced Fluid | 1,277 ft |
| **Radius of Emplaced Fluid** | **0.242 miles** |

### *3.14 Chapter 4, Section 5(c)(xii)*

**The depth and areal extent of all usable fresh and potable water (USDW) underlying the area proposed for exemption.**

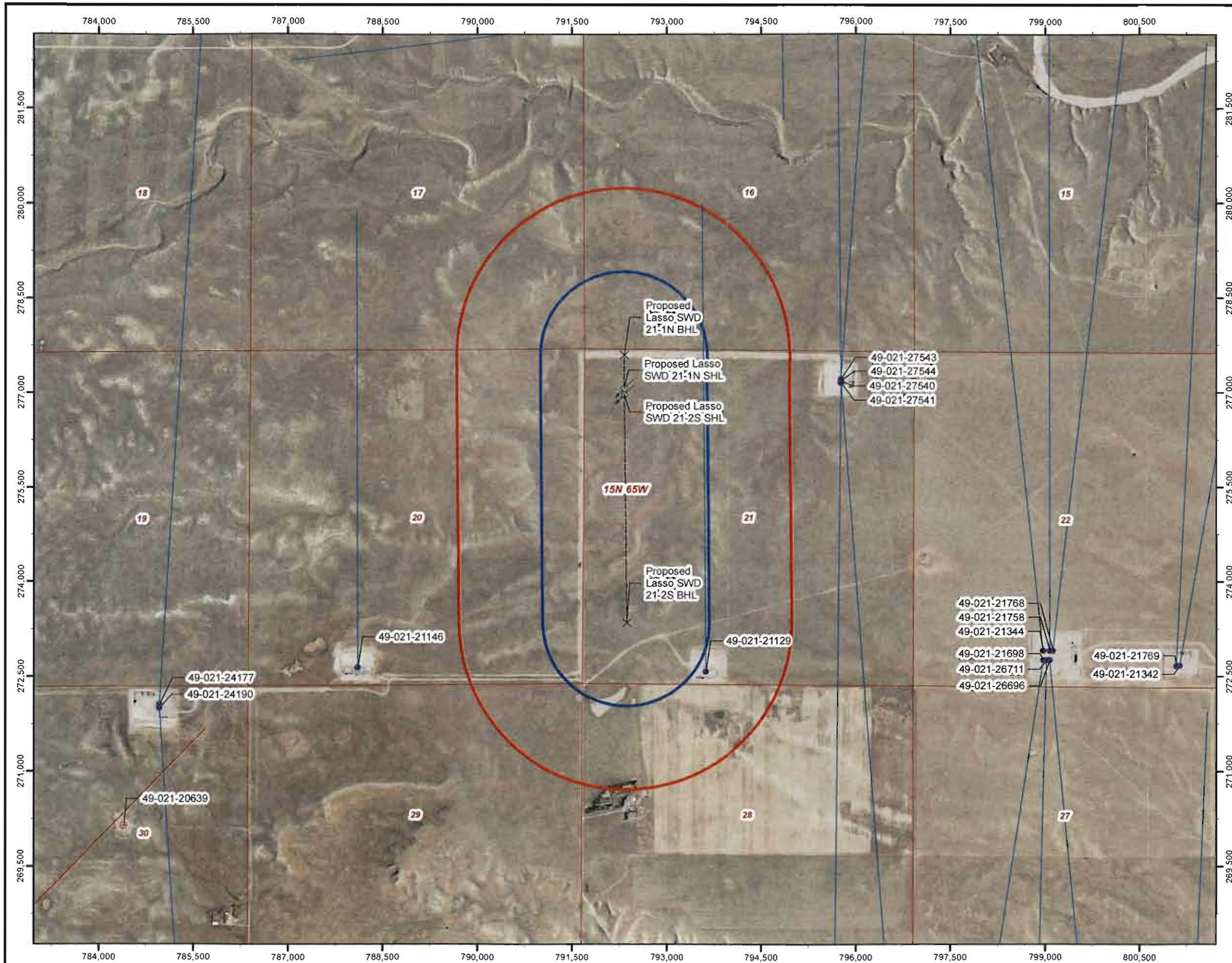
Additional information regarding USDW information is provided in Section 2.6. A water rights search in the nine-section area of the proposed disposal well indicates that all water supply wells authorized by the SEO have been completed at depths of less than 200 feet.

See response 2.6 of this document regarding Chapter 4, Section 12(b) requirements wherein the Tertiary Aquifer that includes the Ogallala, Arikaree, and White River Formations are identified as USDWs in the area that provide regional water supply. The lowermost USDW in the area has been identified as the Fox Hills Sandstone with a formation top at approximately 1,600 feet, that overlies the Pierre Shale, at a depth of approximately 1,900 feet. Groundwater at these depths in the Fox Hills is not utilized as water supply, though water quality in this zone is likely relatively fresh (<3,000 mg/L TDS).

### *3.15 Chapter 4, Section 5(c)(xiii)*

**An Operator or Owner who files an application for approval of a disposal well which is within a one-half (1/2) mile radius of a well producing from the proposed disposal zone shall give notice of the application to the royalty and overriding royalty interest owners within said radius unless the wells are located within a unit.**

The ½-mile Area of Review radii are shown on Exhibit G-1. Information regarding mineral owners, working interest owners, and surface owners within a ½-mile radius of the well are provided in Appendix C, attached to the Application.




## Legend

- Proposed Surface Hole Location
- Proposed Bottom Hole Location
- Producing Oil Well
- Permanently Abandoned Monitor Well
- Proposed Straight-Line Wellbore Trace
- Straight-Line Wellbore Trace
- Abandoned Wellbore Trace
- 1/4-Mile Radius from Lasso SWD 21 Wells
- 1/2-Mile Radius from Lasso SWD 21 Wells

Note:
Radii extend from SHLs, BHLs, and straight-line wellbore traces of the proposed Lasso SWD 21 wells.

Well data from WOGCC, downloaded 09/24/2020. Last modified 09/03/2020.

Straight-Line wellbore traces represent the relationship of surface hole locations to corresponding bottom hole locations and do not represent the true wellbore path.

0 750 1,500 2,250 3,000 Feet

1 inch = 1,500 feet

Coordinate System NAD 1983 StatePlane Wyoming East FIPS 4901 Feet

Aerial Imagery Source. NAIP - USDA Conus Prime

# SAMSON EXPLORATION

Exhibit G-1
Lasso Section 21 SWD Wells

2020 Lasso SWD 21 Wells Class II Application

| | |
|---|---|
| Scale. 1:18,000 | Date October 2020 |
| ExG-01_2020_Lasso_SWD_21.mxd | By WEK Checked AP |

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303-290-0414

| ERA | PER. | FORMATION | THICKNESS (ft) |
|---|---|---|---|
| CEN. | QUAT. TERT. | Undiff. | 0-395 |
| | | Dawson / Denver / Arapahoe | 0-1380 |
| MESOZOIC | CRETACEOUS | Laramie | 0-100 |
| | | Fox Hills Ss. | 0-150 |
| | | Pierre Shale | 985-8200 |
| | | Niobrara | 20-370 |
| | | Codell Sandstone | 0-20 |
| | | Carlile Shale | 40-100 |
| | | Greenhorn Ls. | 200-280 |
| | | Graneros / Mowry Shale | 165-215 |
| | | Dakota Group | 200-490 |
| | JUR. | Morrison | 90-245 |
| | | Entrada | 0-130 |
| | TRI. | Jelm | 0-130 |
| | | Lykins/Blaine | 490-655 |
| PALEOZOIC | PERM. | Lyons | 20-200 |
| | | Satanka / Owl Canyon | 100-245 |
| | | Ingleside | 100-330 |
| | PENN. | Fountain Formation | 100-1200 |
| PRECAMBRIAN | | | |

Modified From http://www.searchanddiscovery.net/documents/2006/06064ethridge/images/02.htm

**SAMSON EXPLORATION**

Exhibit G-2
Regional Stratigraphic Column

2020 Lasso SWD 21 Wells Class II Application

| Scale: NTS | Date: October 2020 | |
|---|---|---|
| ExG-02_2020_Lasso_SWD_21.pdf | By: WEK | Checked: AP |

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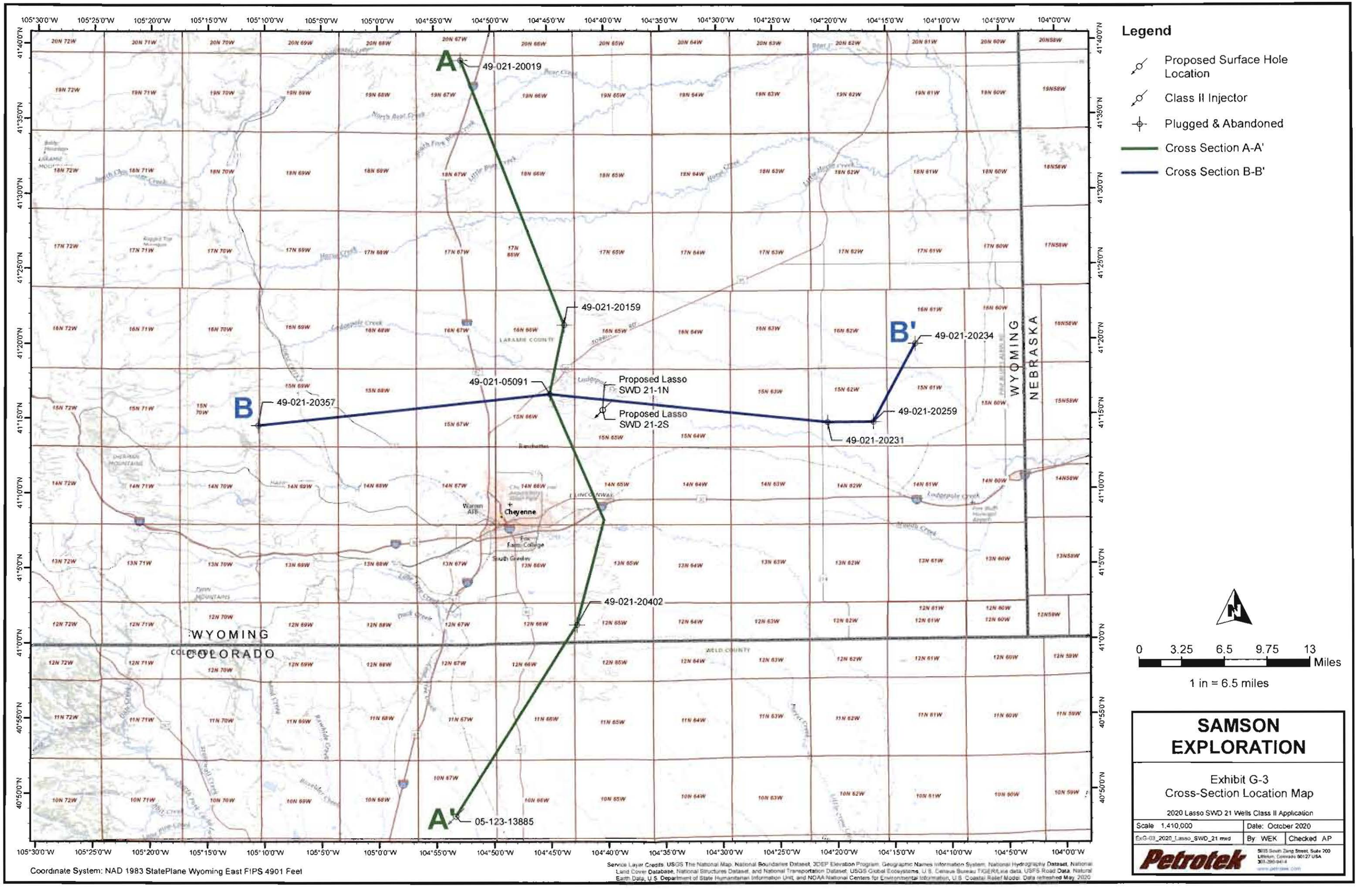


Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet

Service Layer Credits: USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed May, 2020.

# SAMSON EXPLORATION

Exhibit G-3
Cross-Section Location Map

2020 Lasso SWD 21 Wells Class II Application

| | |
|---|---|
| Scale 1:410,000 | Date: October 2020 |
| ExG-03_2020_Lasso_SWD_21.mxd | By WEK \| Checked AP |

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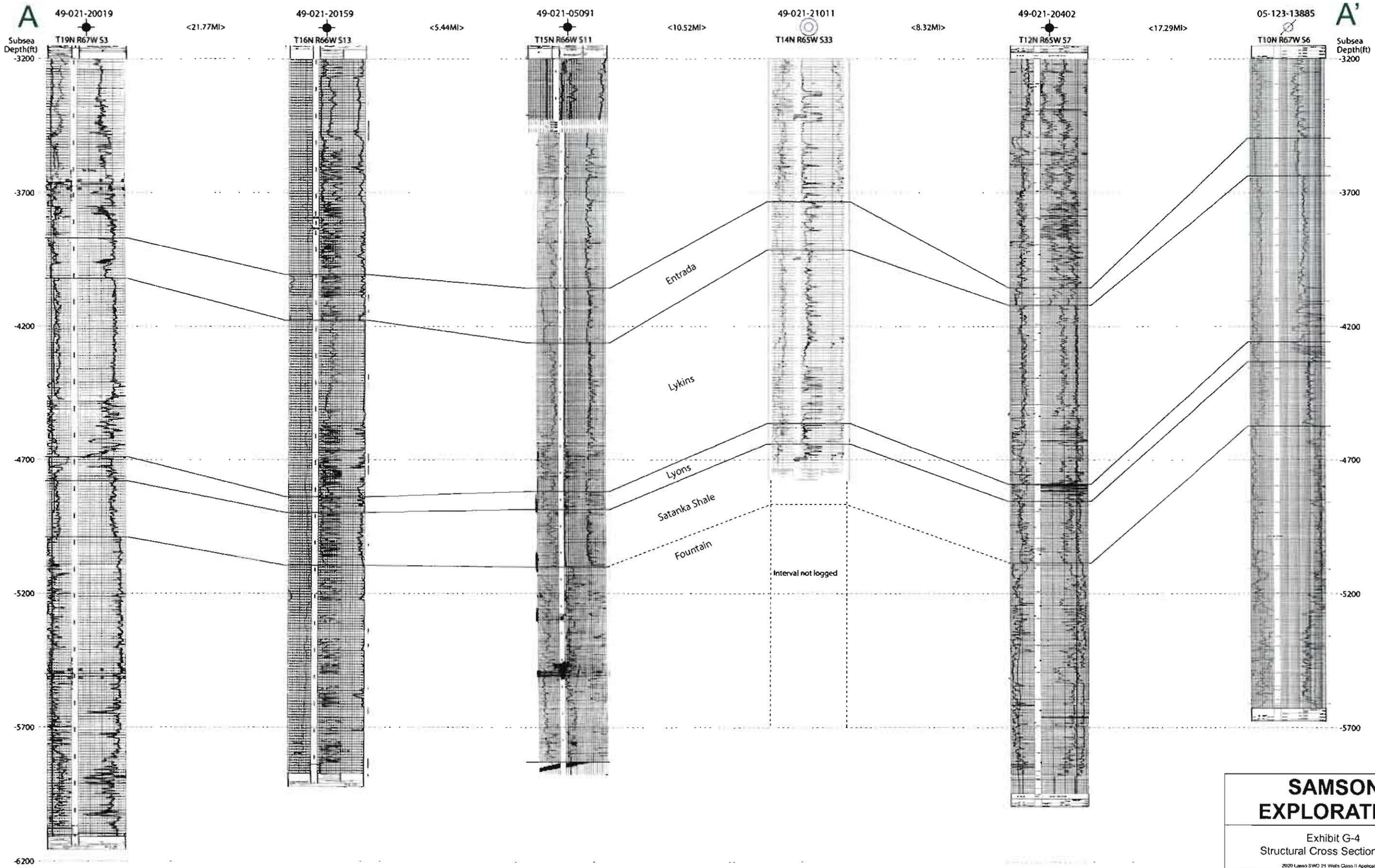


# SAMSON EXPLORATION

Exhibit G-4
Structural Cross Section A - A'

2020 Lasso SWD 21 Wells Class II Application

| | | |
|---|---|---|
| Scale NTS | Date: October 2020 | |
| ExG-04_2020_Lasso_SWD_21.pdf | By: WEK | Checked. AP |

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B

B'

| 49-021-20357 | 49-021-05091 | 49-021-20231 | 49-021-20259 | 49-021-20234 |
|---|---|---|---|---|
| T15N R70W S25 | T15N R66W S11 | T15N R62W S29 | T15N R62W S26 | T16N R61W S28 |

<22.38Mi> <21.33Mi> <3.49Mi> <6.82Mi>

Subsea Depth(ft)

1200
700
200
-300
-800
-1300
-1800
-2300
-2800
-3300
-3800
-4300
-4800
-5300

Entrada
Lykins
Lyons
Satanka Shale
Fountain

PETRA 6/30/2020 12:36:31 PM

# SAMSON EXPLORATION

Exhibit G-5
Structural Cross Section B - B'

2020 Lasso SWD 21 Wells Class II Application

| Scale: See Vertical Scale | Date: October 2020 | |
|---|---|---|
| ExG-05_2020_Lasso_SWD_21.pdf | By: WEK | Checked: AP |

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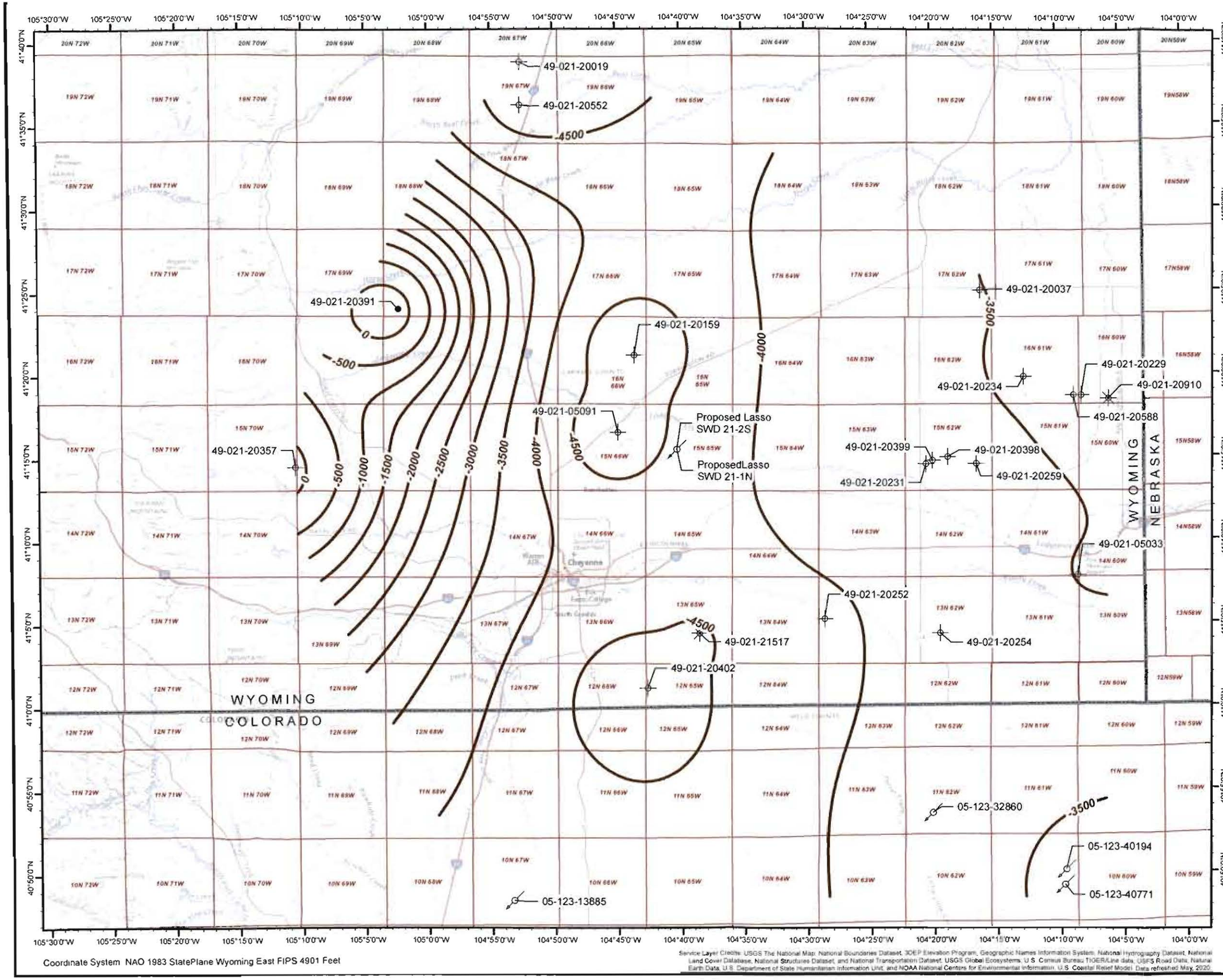


## Legend

- Proposed Surface Hole Location
- Class II Injector
- Oil Well
- Plugged & Abandoned
- Shut-in
- Lyons Structure Contour [feet AMSL]

Contour Interval = 500'

0 3.25 6.5 9.75 13 Miles

1 in = 6.5 miles

# SAMSON EXPLORATION

Exhibit G-6
Structure Contour Map
Top of Lyons Sandstone
2020 Lasso SWD 21 Wells Class II Application

| | | |
|---|---|---|
| Scale 1.410,000 | Date: October 2020 | |
| ExG-06_2020_Lasso_SWD_21.mxd | By: WEK | Checked: AP |

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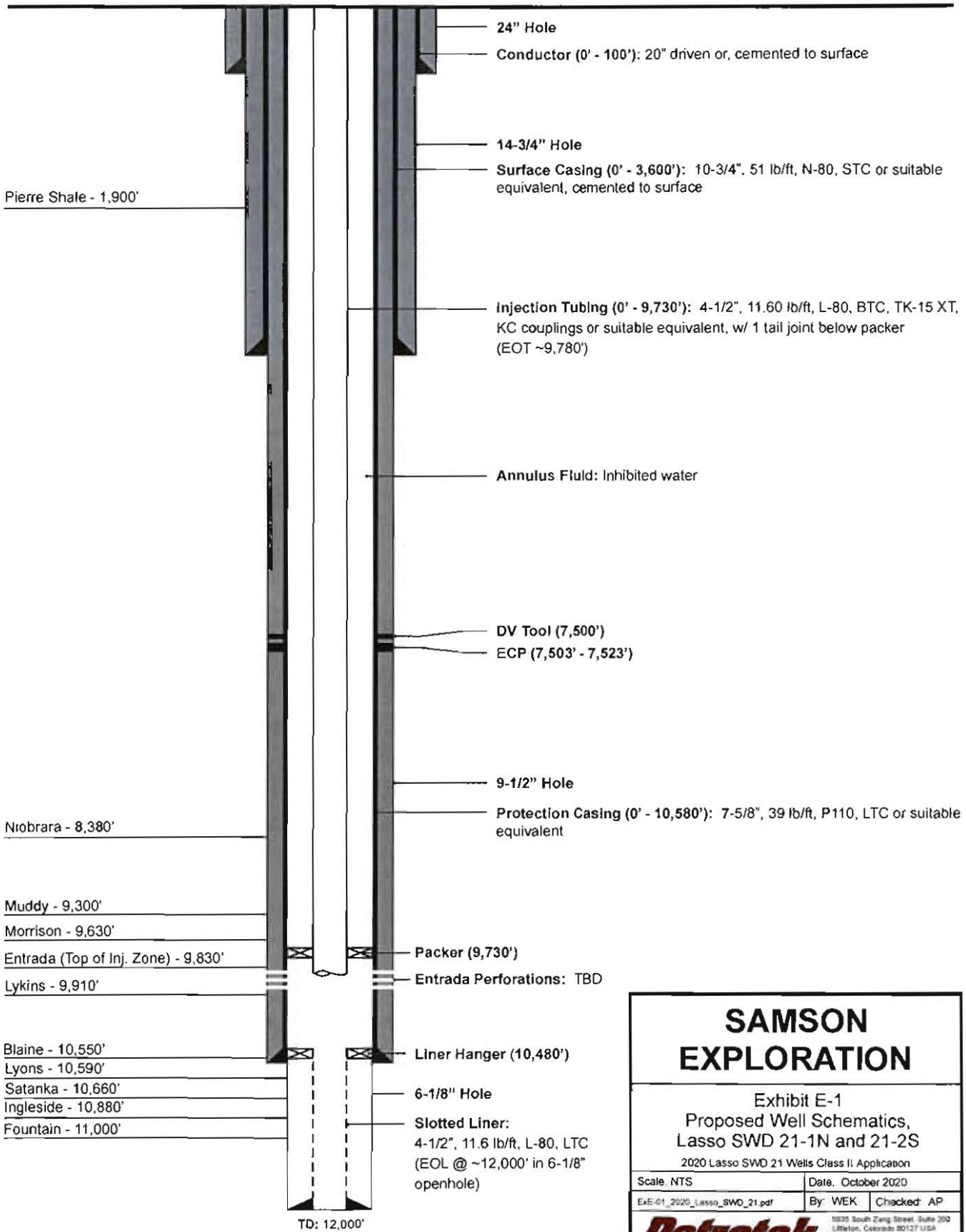
Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet

Service Layer Credits: USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed May, 2020.

Sec. 21, T15N, R65W 6th PM
Laramie County, Wyoming

All depths are TVD referenced to 5,918' GL.




NOT TO SCALE

# SAMSON EXPLORATION

Exhibit E-1
Proposed Well Schematics,
Lasso SWD 21-1N and 21-2S

2020 Lasso SWD 21 Wells Class II Application

| Scale: NTS | Date: October 2020 | |
|---|---|---|
| ExE-01_2020_Lasso_SWD_21.pdf | By: WEK | Checked: AP |

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# APPENDIX A

## Water Quality Records

## Appendix A. TDS Concentrations, Entrada and the DJ Injection Zone, Weld County, Colorado

| API No. | Name | Sec | Twp | Rng | Formation TDS (mg/L) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Entrada | Lyons | L. Satanka | Wolfcamp | Amazon | Council Grove | Admire | Virgil | Missouri | Des Moines | Fountain | Atoka | Morrow | Penn. |
| 05-123-31035 | SIMBA #1-06 SWD | 6 | 11N | 62W | 38,837 | 229,339 | | | | | | | | | | | | |
| 05-123-40194 | NGL C9 | 13 | 10N | 61W | | 15,744 | 14,464 | 14,016 | 14,016 | 14,016 | | 12,554 | 30,336 | 28,244 | 28,800 | 28,800 | 28,800 | |
| 05-123-40770 | NGL C9B | 24 | 10N | 61W | | 15,744 | 14,464 | 14,016 | 14,016 | 14,016 | 12,544 | 12,544 | 30,336 | 28,224 | 30,336 | 28,800 | | |
| 05-123-40630 | Horsetail #19N-1924M-R | 19 | 10N | 57W | 13,992 | 18,770 | 18,770 | | 34,450 | | | | | | | | | |
| 05-123-37495 | Razor #26J-2633L | 26 | 10N | 58W | 17,310 | 62,470 | | | 45,160 | | | | | | | | | |
| 05-123-22125 | Gillette*Lois #1 | 9 | 9N | 61W | | 100,000 | | | | | | | | | | | | |
| 05-123-37374 | Wildhorse #16-13L | 16 | 9N | 59W | 12,310 | 20,010 | | | | | | | | | | | | |
| 05-123-21426 | CROISSANT 1 | 26 | 9N | 62W | | 116,000 | | | | | | | | | | | | |
| 05-123-05541 | 1 UPR | 22 | 8N | 66W | | 27,228 | | | | | | | | | | | | |
| 05-123-39770 | EWS 1 | 26 | 8N | 60W | | 13,952 | 21,888 | 10,560 | 10,560 | 10,560 | 12,224 | 12,224 | 12,224 | 16,448 | | 28,736 | 13,504 | |
| 05-123-05463 | 2UPR | 31 | 8N | 66W | | 27,228 | | | | | | | | | | | | |
| 05-123-30293 | Cummins AB #10-1IJ | 10 | 7N | 64W | | | | | 5,600* | 4,000* | 4,100* | 160,000 | 31,000 | | | | | |
| 05-123-40772 | NGL C10 | 35 | 7N | 65W | | 51,000 | 51,000 | 51,000 | 14,000 | 14,000 | 14,000 | 14,000 | | 13,000 | 14,000 | 13,000 | | |
| 05-123-32207 | NGL C7A | 34 | 7N | 63W | | 19,383 | 19,383 | 3,814* | 4,179* | 4,179* | 11,441 | 11,441 | 12,871 | | 14,585 | | | |
| 05-123-25694 | Synergy Disposal 15-18 I | 18 | 6N | 63W | | 29,600 | | | | | | | | | | | | |
| 05-123-42210 | NGL Apollo | 18 | 6N | 63W | | 13,568 | 3,520* | 3,520* | 3,520* | 3,520* | 3,520* | 32,448 | 32,448 | 67,008 | 32,448 | 67,008 | | |
| 05-123-26604 | Johnson #22-34I | 22 | 6N | 65W | | 49,487 | | | | | | | | | | | | |
| 05-123-12448 | NGL C4 | 26 | 6N | 65W | | 116,534 | | | | | | | | | | | | |
| 05-123-37808 | EWS 2 | 35 | 6N | 65W | | 186,748 | 111,709 | 148,166 | 151,057 | 151,057 | 143,745 | 155,862 | 155,862 | | 53,820 | | | |
| 05-123-27116 | HPD Kersey 1 | 25 | 5N | 65W | 11,500 | 117,300 | | | 51,800 | | | | | | 43,500 | | | |
| 05-123-41201 | NGL C12 | 27 | 5N | 63W | | | | | 43,500 | 43,500 | | 91,500 | 127,000 | 127,000 | 91,500 | 44,400 | | |
| 05-123-38533 | NGL C11 | 27 | 5N | 61W | | 7,198 | 6,061* | 3,688* | 3,688* | 3,688* | 7,211 | 7,211 | 7,553 | 7,553 | | 9,338 | 10,048 | |
| 05-123-16804 | Conquest SWD 1-8 | 8 | 4N | 64W | 13,500 | 29,443 | | | | | | | | | | | | |
| 05-123-29536 | NGL C1B | 8 | 4N | 64W | | | | | 17,586 | 17,586 | | | 12,394 | | | | | |
| 05-123-40377 | NGL C1C | 8 | 4N | 64W | | 19,762 | 29,850 | 25,920 | 25,920 | 25,920 | 21,302 | 21,302 | 23,223 | 20,642 | 23,223 | 20,642 | 20,642 | |
| 05-123-23038 | NGL C1A | 8 | 4N | 64W | | 29,443 | | | | | | | | | | | | |
| 05-123-37120 | EWS 3 | 23 | 4N | 66W | | 50,244 | 82,179 | 37,942 | 21,950 | 41,158 | 85,625 | 42,600 | 42,600 | | 47,128 | | 47,128 | |
| 05-123-42811 | NGL C3B | 29 | 4N | 65W | | 14,570 | 98,756 | 99,945 | 99,945 | 99,945 | 107,500 | 107,500 | 102,400 | | 109,440 | | | |
| 05-123-31735 | NGL C3A | 32 | 4N | 65W | | 14,570 | 98,756 | 99,945 | | 99,945 | | | | | | | | |
| 05-123-19688 | NGL C3 | 32 | 4N | 65W | | 12,000 | | | | | | | | | | | | |
| 05-123-30367 | LSWD#1 | 18 | 3N | 64W | 14,000 | 65,646 | | | | | | 26,741 | | | | | | |
| 05-123-29168 | HPD Platteville 1 | 24 | 3N | 66W | 19,050 | 14,650 | | | 21,950 | 41,158 | | | | | 24,000 | | | |
| 05-123-39710 | HPD Platteville 2 | 24 | 3N | 66W | | 14,650 | | | | | | | | | 24,200 | | | |
| 05-123-26004 | NGL C6 | 30 | 3N | 65W | | 16,960 | | | 12,846 | 12,846 | | | | | 13,526 | | | |
| 05-123-40968 | NGL C6A | 30 | 3N | 65W | | 16,960 | 13,526 | 12,846 | 12,846 | 12,846 | 36,142 | 26,665 | 44,879 | 40,693 | 44,879 | 40,693 | | |
| 05-123-44047 | EWS 4A | 17 | 2N | 63W | | 20,090 | 16,300 | 16,300 | 34,890 | 34,890 | 34,890 | 16,290 | 16,290 | | 17,190 | | | |
| 05-123-15621 | Wattenberg SWD#1 | 19 | 2N | 66W | 17,400 | 16,227 | | | | | | | | | | | | |
| 05-123-37996 | KMG #16-24i | 24 | 2N | 65W | 10,490 | 11,000 | 11,000 | 13,920 | | | | | | | | | | 21,360 |
| 05-123-40973 | C5A | 29 | 2N | 64W | | 11,000 | 11,000 | 15,000 | 15,000 | 15,000 | 15,000 | 14,000 | 14,000 | | 14,000 | | | |
| 05-123-44836 | C5B | 29 | 2N | 64W | | 11,000 | 11,000 | 15,000 | 15,000 | 15,000 | 15,000 | 14,000 | 14,000 | | 14,000 | | | |
| 05-123-40645 | NGL C5 | 29 | 2N | 64W | | 11,000 | 11,000 | 15,000 | 15,000 | 15,000 | 15,000 | 14,000 | 14,000 | | 14,000 | | | |
| 05-123-30012 | KerrMcGee 19-3i | 3 | 1N | 68W | 20,400 | 20,400 | | | | | | | | | 12,260 | | | |
| 05-123-14291 | Suckla Farms Inj Well #1 | 10 | 1N | 67W | | 38,610 | | | | | | | | | | | | |
| 05-123-18763 | NGL C2 | 28 | 1N | 67W | | 19,654 | | | | | | | | | | | | |
| 05-123-42698 | NGL C2C | 28 | 1N | 67W | | 57,300 | 57,300 | | | | | | | | 62,800 | | | |

NOTE: this data is pulled from COGCC UIC facility scout cards.

* These data results are suspect and most likely are the result of mud filtrate inclusion in the collected sample.



Petrotek

# APPENDIX B

## Identified Source Wells and Available Water Quality Data

**Potential Source Wells,**
**Lasso SWD 21-1N and 21-2S Class II Disposal Wells**

| LEASE NAME | RESERVOIR | API | WATER ANALYSIS | DATE |
|---|---|---|---|---|
| BRIDLE 0214 10H | CODELL | 49021265630000 | N | |
| BUCKAROO 2215 2NH | CODELL | 49021280000000 | N | |
| BUCKAROO 2536 12SH | CODELL | 49021226670000 | N | |
| BUCKAROO 2635 12H | CODELL | 49021241470000 | N | |
| BUCKAROO 2734 6SH | CODELL | 49021278140000 | N | |
| BUCKAROO 2833 12SH | CODELL | 49021277680000 | N | |
| BUTTERFLY 13-1-2-1CH | CODELL | 49021215700000 | Y | 4/11/2017 |
| BUTTERFLY 13-24-2-2CH | CODELL | 49021215690000 | Y | 4/11/2017 |
| CHASTANET 9-16-2-1CH | CODELL | 49021210550000 | N | |
| DEWEY 7-9-1CH | CODELL | 49021210020000 | Y | 4/10/2014 |
| ELMO 21-16-14-1CH | CODELL | 49021211290000 | Y | 9/17/2014 |
| GRACE BAY 20-17-14-1CH | CODELL | 49021211460000 | N | |
| LASSO 1609 10NH | CODELL | 49021275400000 | N | |
| LASSO 1609 12NH | CODELL | 49021275410000 | N | |
| LA5SO 1918 12NH | CODELL | 49021241770000 | N | |
| LASSO 2128 10SH | CODELL | 49021275430000 | N | |
| LASSO 2128 12SH | CODELL | 49021275440000 | N | |
| LASSO 3031 12SH | CODELL | 49021241900000 | N | |
| MAGEE 9-16-2-1CH | CODELL | 49021211350000 | N | |
| RIMROCK 33-28-6-1CH | CODELL | 49021210650000 | N | |
| RIMROCK 33-4-6-2CH | CODELL | 49021210660000 | Y | 4/10/2014 |
| RINCON 11-23-15-2CH | CODELL | 49021219480000 | Y | 4/11/2017 |
| ROSEMARY 31-3-1CH | CODELL | 49021210180000 | Y | 4/10/14, pg 4 |
| TALLOW 0433 #10H | CODELL | 49021238700000 | Y | 1/18/2017 |
| TALLOW 0433 #12H | CODELL | 49021238710000 | Y | 1/18/2017 |
| TALLOW 0433 #8H | CODELL | 49021238720000 | N | |
| TALLOW 0805 10NH | CODELL | 49021275200000 | N | |
| TALLOW 0805 12NH | CODELL | 49021275210000 | N | |
| TALLOW 0805 2NH | CODELL | 49021245180000 | N | |
| TALLOW 0916 #10H | CODELL | 49021226520200 | Y | 1/18/2017 |
| TALLOW 0916 #12H | CODELL | 49021226510000 | N | |
| TALLOW 1720 10SH | CODELL | 49021275250000 | N | |
| TALLOW 1720 12SH | CODELL | 49021275260000 | N | |
| TALLOW 1720 2SH | CODELL | 49021245030000 | N | |
| WARREN 17-1CH | CODELL | 49021209830000 | Y | 7/?/2013 |
| WHITBY 32-5-6-2CH | CODELL | 49021211360000 | Y | 10/1/2014 |
| TALLOW 0916 #11H | NIOBRARA C | 49021238750000 | N | |
| TALLOW 0916 #13H | NIOBRARA C | 49021226530000 | N | |
| TALLOW 0916 #7H | NIOBRARA C | 49021238730000 | N | |
| BUCKAROO 0508 #7H | NIOBRARA C | 49021245720000 | N | |
| BUCKAROO 2635 13H | NIOBRARA C | 49021241480000 | N | |

ENERGYPTL, LLC
PRECISION TESTING AND LABORATORY

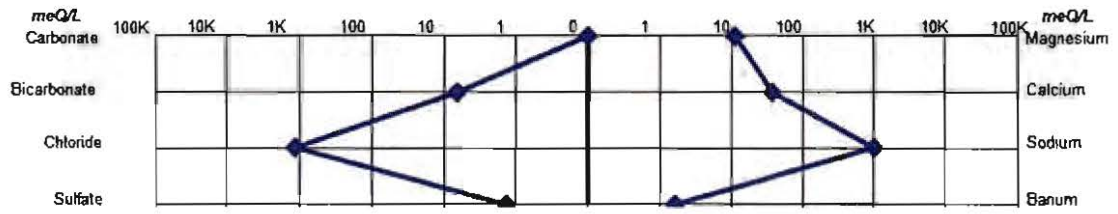
| | |
|---|---|
| **To:** Smart Chemical Services | **Lab #:** 825-170331R002 |
| **Lease:** Ward Petroleum | **Sample Date:** 3/28/17 |
| **Well No.:** Butterfly 13-1-2-1CH | **Sample Analyzed:** 4/05/17 |
| **Location:** Treater | **Analyzed By:** V.W./G.R. |

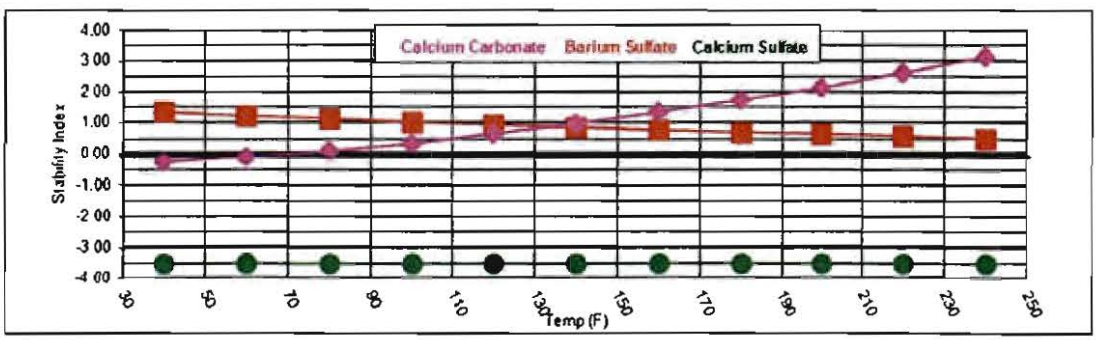
| Analysis | |
|---|---|
| Specific Gravity (74°F) | 1.0328 |
| pH, Field | 7.4 |
| Calcium Carbonate S.I. @ 80°F (Stiff-Davis) | 0.12 |
| Calcium Carbonate S.I. @ 140°F (Stiff-Davis) | 0.96 |
| Calcium Sulfate Scaling Tendency | no |
| Barium Sulfate Scaling Tendency | yes |
| | |
| **Dissolved Gases** | **mg/l** |
| Hydrogen Sulfide ($H_2S$), Field | 0 |
| Carbon Dioxide ($CO_2$), Field | 132 |
| Dissolved Oxygen ($O_2$) | N/A |

| Probable Mineral Comp. | mg/l |
|---|---|
| $Ca(HCO_3)_2$ | 518.51 |
| $CaSO_4$ | 155.90 |
| $CaCl_2$ | 1708.84 |
| $Mg(HCO_3)_2$ | 0.00 |
| $MgSO_4$ | 0.00 |
| $MgCl_2$ | 523.95 |
| $NaHCO_3$ | 0.00 |
| $NaSO_4$ | 0.00 |
| NaCl | 64654.94 |
| | |
| | |

| Cations | mg/l | meq/l | | Anions | mg/l | meq/l |
|---|---|---|---|---|---|---|
| Sodium (Na) | 23827.79 | 1036.44 | | Chloride (Cl) | 40702.27 | 1145.25 |
| Calcium (Ca) | 745.25 | 37.08 | | Bicarbonate (HCO3), Field | 390.40 | 6.40 |
| Magnesium (Mg) | 133.71 | 11.00 | | Carbonate (CO3) | 0.00 | 0.00 |
| Potassium (K) | 232.25 | 5.94 | | Hydroxyl (OH) | 0.00 | 0.00 |
| Iron (Fe) | 54.76 | 1.96 | | Sulfate (SO4) | 64.16 | 1.34 |
| Barium (Ba) | 112.43 | 1.64 | | | | |
| Manganese (Mn) | 1.32 | 0.05 | | | | |
| Strontium (Sr) | 192.71 | 4.40 | | | | |

| | |
|---|---|
| Total Dissolved Solids, Calculated (mg/l) | 66264 |
| Total Hardness as mg/l $CaCO_3$ | 2411 |
| Resistivity (Ω/m) @ 75°F | 0.094 |




Generated by Energy Precision Testing, 615 Price Rd., Pampa, TX 79065
Certified QA/QC Geochemist, Neil Ray

ENERGYPTL, LLC
PRECISION TESTING AND LABORATORY

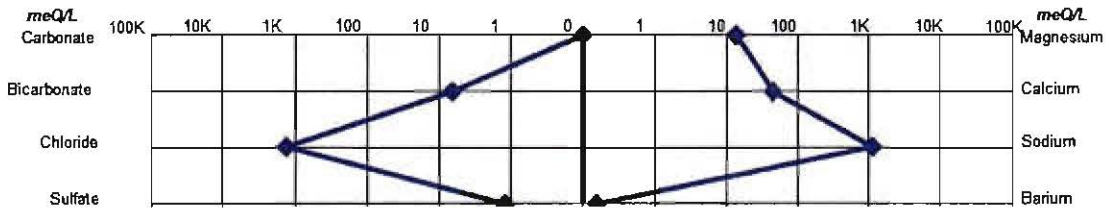
| | |
|---|---|
| **To:** Smart Chemical Services | **Lab #:** 825-170331R001 |
| **Lease:** Ward Petroleum | **Sample Date:** 3/28/17 |
| **Well No.:** Butterfly 13-24-2-2CH | **Sample Analyzed:** 4/05/17 |
| **Location:** Treater | **Analyzed By:** V.W./G.R. |

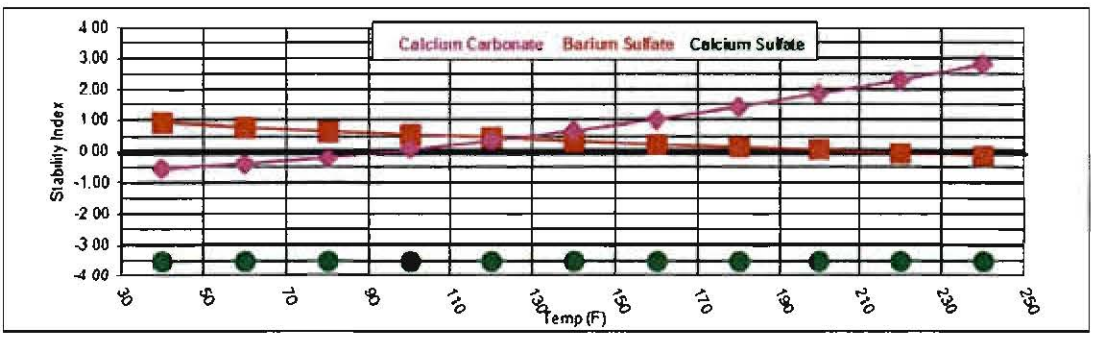
| Analysis | |
|---|---|
| Specific Gravity (74°F) | 1.0285 |
| pH, Field | 7 |
| Calcium Carbonate S.I. @ 80°F (Stiff-Davis) | -0.19 |
| Calcium Carbonate S.I. @ 140°F (Stiff-Davis) | 0.65 |
| Calcium Sulfate Scaling Tendency | no |
| Barium Sulfate Scaling Tendency | yes |
| | |
| **Dissolved Gases** | **mg/l** |
| Hydrogen Sulfide ($H_2S$), Field | 0 |
| Carbon Dioxide ($CO_2$), Field | 88 |
| Dissolved Oxygen ($O_2$) | N/A |

| Probable Mineral Comp. | mg/l |
|---|---|
| $Ca(HCO_3)_2$ | 518.51 |
| $CaSO_4$ | 140.39 |
| $CaCl_2$ | 2190.78 |
| $Mg(HCO_3)_2$ | 0.00 |
| $MgSO_4$ | 0.00 |
| $MgCl_2$ | 627.44 |
| $NaHCO_3$ | 0.00 |
| $NaSO_4$ | 0.00 |
| NaCl | 74349.21 |
| | |
| | |

| Cations | mg/l | meq/l | | Anions | mg/l | meq/l |
|---|---|---|---|---|---|---|
| Sodium (Na) | 26264.17 | 1142.42 | | Chloride (Cl) | 46976.92 | 1321.80 |
| Calcium (Ca) | 919.27 | 45.73 | | Bicarbonate (HCO3), Field | 390.40 | 6.40 |
| Magnesium (Mg) | 160.12 | 13.18 | | Carbonate (CO3) | 0.00 | 0.00 |
| Potassium (K) | 248.86 | 6.37 | | Hydroxyl (OH) | 0.00 | 0.00 |
| Iron (Fe) | 22.83 | 0.82 | | Sulfate (SO4) | 57.78 | 1.20 |
| Barium (Ba) | 12.98 | 0.19 | | | | |
| Manganese (Mn) | 0.47 | 0.02 | | | | |
| Strontium (Sr) | 222.68 | 5.08 | | | | |

| | |
|---|---|
| Total Dissolved Solids, Calculated (mg/l) | 75054 |
| Total Hardness as mg/l $CaCO_3$ | 2955 |
| Resistivity (Ω/m) @ 75°F | 0.086 |




Generated by Energy Precision Testing, 615 Price Rd., Pampa, TX 79065
Certified QA/QC Geochemist, Neil Ray

# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| **Client:** | Cirque Resources LP | | |
| **Project:** | Not Indicated | **Report Date:** | 04/10/14 |
| **Client Sample ID:** | Dewey 7-9-1CH | **Collection Date:** | 03/21/14 11:30 |
| **Location:** | | **Date Received:** | 03/24/14 |
| **Samp FRQ/Type:** | | **Matrix:** | Aqueous |
| **Lab ID:** | G14030467-003 | **Sampled By:** | Myron Means |

| Analyses | Result | Units | RL | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|---|
| **MAJOR IONS, DISSOLVED** | | | | | | |
| Bicarbonate as HCO3 | 417 | mg/L | 5 | | A2320 B | 03/25/14 16:09 / blb |
| Carbonate as CO3 | ND | mg/L | 5 | | A2320 B | 03/25/14 16:09 / blb |
| Hydroxide as OH | ND | mg/L | 5 | | A2320 B | 03/25/14 16:09 / blb |
| Chloride | 33200 | mg/L | 100 | D | E300.0 | 03/25/14 18:54 / blb |
| Sulfate | ND | mg/L | 10 | D | E300.0 | 03/26/14 13:00 / blb |
| Calcium | 720 | mg/L | 1 | | E200.7 | 03/26/14 13:31 / eli-b |
| Magnesium | 102 | mg/L | 4 | D | E200.7 | 03/26/14 13:31 / eli-b |
| Potassium | 163 | mg/L | 8 | D | E200.7 | 03/26/14 13:31 / eli-b |
| Sodium | 19300 | mg/L | 70 | D | E200.7 | 03/26/14 13:31 / eli-b |
| **METALS, DISSOLVED** | | | | | | |
| Barium | 65.4 | mg/L | 0.05 | | E200.7 | 03/26/14 13:31 / eli-b |
| Iron | 0.7 | mg/L | 0.4 | D | E200.7 | 03/26/14 13:31 / eli-b |
| Strontium | 161 | mg/L | 0.02 | D | E200.7 | 03/26/14 13:31 / eli-b |
| **METALS, TOTAL RECOVERABLE** | | | | | | |
| Barium | 71.8 | mg/L | 0.05 | | E200.7 | 03/27/14 20:40 / eli-b |
| Iron | 40.3 | mg/L | 0.4 | D | E200.7 | 03/27/14 20:40 / eli-b |
| Manganese | 0.540 | mg/L | 0.001 | | E200.8 | 03/27/14 23:16 / eli-b |
| Strontium | 166 | mg/L | 0.01 | | E200.8 | 03/27/14 23:16 / eli-b |
| **NON-METALS** | | | | | | |
| Alkalinity, Total as CaCO3 | 342 | mg/L | 5 | | A2320 B | 03/25/14 16:09 / blb |
| Conductivity @ 25 C | 72700 | umhos/cm | 10 | E | A2510 B | 03/24/14 17:16 / blb |
| pH | 6.44 | s.u. | 0.01 | H | A4500-H B | 03/24/14 17:16 / blb |
| Solids, Total Dissolved TDS @ 180 C | 53600 | mg/L | 1000 | | A2540 C | 03/25/14 08:47 / blb |
| Resistivity @ 68 F | 0.151 | ohm-m | | | E120.1 | 03/24/14 17:16 / tla |
| Solids, Total Dissolved - Calculated | 53600 | mg/L | 1 | | A1030 E | 04/07/14 09:28 / tla |
| **DATA QUALITY** | | | | | | |
| A/C Balance | -3.31 | % | | | A1030 E | 04/07/14 09:28 / tla |
| Anions | 948 | meq/L | | | A1030 E | 04/07/14 09:28 / tla |
| Cations | 887 | meq/L | | | A1030 E | 04/07/14 09:28 / tla |

**Report Definitions:**

RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
H - Analysis performed past recommended holding time
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
E - Estimated value. Result exceeds the instrument upper quantitation limit.

Myron Means
Cirque Resources LP
475 17th St. Suite 1600
Denver, CO 80202

Date: September 17, 2014
Request Number: 33236
Date Received: 8-26-14
Matrix: Water

**REPORT OF ANALYSIS**

Lab Number: P2832
**Sample ID: Elmo 8-26-14 0710 water**

| Cations | Result, mg/L | Result, meq | Method | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Calcium | 606* | 30.2 | EPA 6010C | 8/29/2014 | CB |
| Magnesium | 84.3* | 6.94 | EPA 6010C | 8/29/2014 | CB |
| Sodium | 15,230* | 660 | EPA 6010C | 8/29/2014 | CB |
| Potassium | 86.7* | 2.22 | EPA 6010C | 8/29/2014 | CB |
| Dissolved Iron | 2.25* | 0.08 | EPA 3010/6010C | 9/10/2014 | CB |
| Dissolved Barium | 63.6* | 0.9 | EPA 6010C | 9/10/2014 | CB |
| Cations Sum | ------- | 699 | | | |

| | | | | | |
|---|---|---|---|---|---|
| Dissolved Strontium | 126* | ------- | EPA 6020C | 9/10/2014 | CB |

| Anions | | | | | |
|---|---|---|---|---|---|
| Bicarbonate (as CaC03) | 599 | 9.98 | EPA 310.1 | 8/29/2014 | DA |
| Hydroxide (as CaC03) | 0 | 0 | EPA 310.1 | 8/29/2014 | DA |
| Carbonate (as CaC03) | 0 | 0 | EPA 310.1 | 8/29/2014 | DA |
| Total Alkalinity (as CaC03) | 599 | 9.98 | EPA 310.1 | 8/29/2014 | DA |
| Chloride | 25,598* | 722 | ASTM D512 | 9/10/2014 | CB |
| Sulfate | 18.0 | 0.37 | EPA 375.3 | 9/10/2014 | CB |
| Anions Sum | ------ | 732 | | | |

| | | | | | |
|---|---|---|---|---|---|
| pH, std. units | 6.88 | ------ | EPA 150.1 | 8/29/2014 | DA |
| Total Dissolved Solids | 41,425* | ------- | EPA 160.1 | 8/29/2014 | DA |
| Conductivity | 76,300 | ------ | EPA 120.1 | 8/29/2014 | DA |

| | Result | Method |
|---|---|---|
| Langalier Saturation Index** | -1.8 | Calculated |

**LSI- Water is under saturated with respect to calcium carbonate. Under saturated water has a tendency to remove existing Calcium Carbonate protective coatings in pipelines and equipment. Water will cause corrosion.

*Results are the average of 2 runs

Monte L. Ellis

End of Report
MLE/tab

Laboratory Manager

**WYOMING ANALYTICAL LABORATORIES, INC.**
1660 Harrison St. Laramie, WY 82070
Wallaramie@wal-lab.com
(307) 742-7995
Fax: (307) 721-8956

Myron Means
Cirque Resources LP
475 17th St. Suite 1600
Denver , CO 80202

Date: September 17, 2014
Request Number: 33236
Date Received: 8-26-14
Matrix: Water

**REPORT OF ANALYSIS**

Lab Number: P2832
**Sample ID: Elmo 8-26-14 0710 water**

| Time Sampled | Sample Date | Sulfur Reducing Bacteria, Approximately cfu/100ml | SRB Comments | Date & Time Started | Date & Time Ended |
|---|---|---|---|---|---|
| 0710 | 8-16-14 | 18,000 | BB/BT | 8-26-14 / 12:30pm | 8-28-14 / 2:00pm |

**SRB Comments**
**BB**: Dense Anaerobic consortium.
**BT**: Aerobic consortium.
FO: Foam Only

Matt L. Ellis.

End of Report
MLE/tab

Laboratory Manager

**WYOMING ANALYTICAL LABORATORIES, INC.**
1660 Harrison St. Wallaramie@wal-lab.com (307) 742-7995
Laramie, WY 82070 Fax: (307) 721-8956

Myron Means
Cirque Resources LP
475 17th St. Suite 1600
Denver , CO 80202

Date: September 17, 2014
Request Number: 33236
Date Received: 8-26-14
Matrix: Oil & Water

**REPORT OF ANALYSIS**

Lab Number: P2832
**Sample ID: Elmo 8-26-14 0710 water**

| | Result | Units | Method | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Sediment | 0.5* | % | D4007 | 8/26/2014 | CB |
| Water | 48.5* | % | D4007 | 8/26/2014 | CB |

Lab Number: P2832
**Sample ID: Elmo 8-26-14 0710 oil**

| | Result | Units | Method | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Total Sulfur | 0.299 | wt% | D2622 (XRF) | 09/10/14 | CW |
| Specific Gravity, 60F/60F | 0.830 | ------ | D1298 | 09/03/14 | RB |
| API | 39.0 | ------ | Calculated | 09/03/14 | RB |
| Pour Point | - 44 | $^{o}$C | D3227 | 09/09/14 | RB |
| Asphaltines | 0.2* | wt.% | D6560 M | 09/04/14 | CB |
| Paraffins | 19.3* | wt.% | Distillation | 09/02/14 | CB |
| Kinematic Viscosity @ 100°F | 5.29 | cP | D445 | 09/04/14 | DL |
| Kinematic Viscosity @ 120°F | 6.30 | cP | D445 | 09/04/14 | DL |
| Saybolt Viscosity @ 100°F | ** | cP | D2161 | ------ | ------ |
| Saybolt Viscosity @ 120°F | ** | cP | D2161 | ------ | ------ |

**Saybolt Viscosity can not be analyzed at these temperatures.

*Results are the average of 2 runs

Marte L. Ellis

End of Report
MLE/tab

Laboratory Manager

**WYOMING ANALYTICAL LABORATORIES, INC.**
1660 Harrison St. Laramie, WY 82070
Wallaramie@wal-lab.com
(307) 742-7995
Fax: (307) 721-8956

Myron Means
Cirque Resources LP
475 17th St. Suite 1600
Denver, CO 80202

Date: September 17, 2014
Request Number: 33236
Date Received: 8-26-14
Matrix: Water

**QUALITY CONTROL**

| P2832 / Water | Result | Dup. Result | RPD | RPD Limit | Lab control sample % | LCS Range % |
|---|---|---|---|---|---|---|
| Calcium, | 602 | 610 | 1.32 | 20 | 103 | 75-125 |
| Magnesium, mg/L | 83.4 | 85.2 | 2.14 | 20 | 107 | 75-125 |
| Sodium, mg/L | 15,170 | 15,290 | 0.79 | 20 | 102 | 75-125 |
| Potassium, mg/L | 86.0 | 87.3 | 1.50 | 20 | 104 | 75-125 |
| Dissolved Iron, mg/L | 2.00 | 2.50 | 18.2 | 20 | 107 | 75-125 |
| Dissolved Barium, mg/L | 63 | 64 | 1.89 | 20 | 113 | 75-125 |
| Dissolved Strontium, mg/L | 125 | 126 | 0.80 | 20 | 110 | 75-125 |

| | Reference | Expected | Value | % Recovery |
|---|---|---|---|---|
| Total Dissolved Solids, mg/L | Wal 4790 | 4790 | 4730 | 99 |
| Conductivity, mg/L | QCI-1096 | 1085 | 1087 | 100 |
| Sulfate, mg/L | WAL1047 | 1047 | 1074 | 103 |
| Total Alkalinity (as CaC03), mg/L | QCI-1096 | 490 | 492 | 100 |
| Chloride, mg/L | QCI-1096 | 299 | 306 | 102 |

| P2832 / Oil & Water | Result | Dup. Result | RPD | RPD Limit |
|---|---|---|---|---|
| Bottom Sediment | 0.5 | 0.5 | 0.00 | 20 |
| Water | 47.5 | 49.5 | 4.12 | 20 |

End of QC Report
MLE/tab

Laboratory Manager

**WYOMING ANALYTICAL LABORATORIES, INC.**
1660 Harrison St. Wallaramie@wal-lab.com (307) 742-7995
Laramie, WY 82070 Fax: (307) 721-8956

ENERGYPTL, LLC
PRECISION TESTING AND LABORATORY

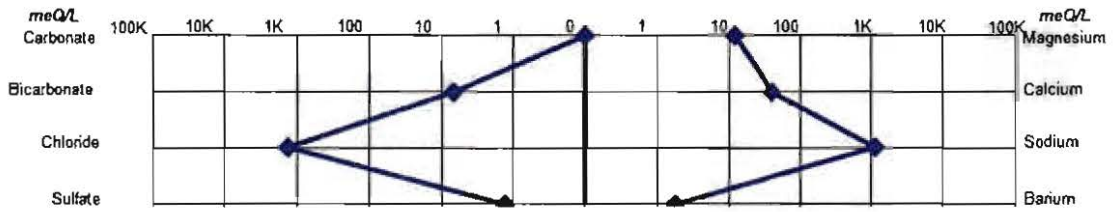
| | |
|---|---|
| **To:** Smart Chemical Services | **Lab #:** 825-170331R003 |
| **Lease:** Ward Petroleum | **Sample Date:** 3/28/17 |
| **Well No.:** Rincon 11-23-15-2CH | **Sample Analyzed:** 4/05/17 |
| **Location:** Treater | **Analyzed By:** V.W./G.R. |

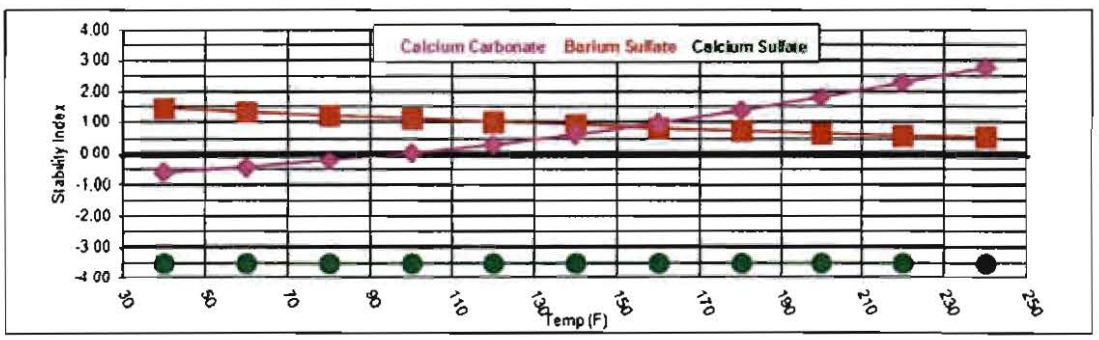
| Analysis | |
|---|---|
| Specific Gravity (74°F) | 1.0216 |
| pH, Field | 7 |
| Calcium Carbonate S.I. @ 80°F (Stiff-Davis) | -0.22 |
| Calcium Carbonate S.I. @ 140°F (Stiff-Davis) | 0.63 |
| Calcium Sulfate Scaling Tendency | no |
| Barium Sulfate Scaling Tendency | yes |
| | |
| **Dissolved Gases** | **mg/l** |
| Hydrogen Sulfide ($H_2S$), Field | 0 |
| Carbon Dioxide ($CO_2$), Field | 88 |
| Dissolved Oxygen ($O_2$) | N/A |

| Probable Mineral Comp. | mg/l |
|---|---|
| $Ca(HCO_3)_2$ | 550.92 |
| $CaSO_4$ | 148.16 |
| $CaCl_2$ | 1862.31 |
| $Mg(HCO_3)_2$ | 0.00 |
| $MgSO_4$ | 0.00 |
| $MgCl_2$ | 571.24 |
| $NaHCO_3$ | 0.00 |
| $NaSO_4$ | 0.00 |
| NaCl | 76769.75 |
| | |
| | |

| Cations | mg/l | meq/l | | Anions | mg/l | meq/l |
|---|---|---|---|---|---|---|
| Sodium (Na) | 26561.89 | 1155.37 | | Chloride (Cl) | 48189.31 | 1355.92 |
| Calcium (Ca) | 808.68 | 40.23 | | Bicarbonate (HCO3), Field | 414.80 | 6.80 |
| Magnesium (Mg) | 145.78 | 12.00 | | Carbonate (CO3) | 0.00 | 0.00 |
| Potassium (K) | 268.75 | 6.88 | | Hydroxyl (OH) | 0.00 | 0.00 |
| Iron (Fe) | 69.51 | 2.49 | | Sulfate (SO4) | 60.98 | 1.27 |
| Barium (Ba) | 121.01 | 1.76 | | | | |
| Manganese (Mn) | 1.14 | 0.04 | | | | |
| Strontium (Sr) | 226.17 | 5.16 | | | | |

| | |
|---|---|
| Total Dissolved Solids, Calculated (mg/l) | 76642 |
| Total Hardness as mg/l $CaCO_3$ | 2619 |
| Resistivity (Ω/m) @ 75°F | 0.084 |




Generated by Energy Precision Testing, 615 Price Rd., Pampa, TX 79065
Certified QA/QC Geochemist, Neil Ray

# ANALYTICAL SUMMARY REPORT

April 10, 2014

Cirque Resources LP
475 17th St Ste 1600
Denver, CO 80202

Work Order: G14030467 Quote ID: G2 - Templates - Gillette

Project Name: Not Indicated

Energy Laboratories Inc. Gillette WY received the following 10 samples for Cirque Resources LP on 3/24/2014 for analysis.

| Lab ID | Client Sample ID | Collect Date | Receive Date | Matrix | Test |
|---|---|---|---|---|---|
| G14030467-001 | Rosemary 31-3-16H | 03/22/14 9:00 | 03/24/14 | Aqueous | Metals by ICP/ICPMS, Dissolved<br>Metals, Total Recoverable<br>Alkalinity<br>Anion - Cation Balance<br>Conductivity<br>Anions by Ion Chromatography<br>pH<br>Metals Digestion by EPA 200.2<br>Preparation, Dissolved Filtration<br>Resistivity<br>ROF-Routine Oilfield Graphs<br>Solids, Total Dissolved<br>Solids, Total Dissolved - Calculated |
| G14030467-002 | Warren 17-1CH | 03/21/14 11:45 | 03/24/14 | Aqueous | Same As Above |
| G14030467-003 | Dewey 7-9-1CH | 03/21/14 11:30 | 03/24/14 | Aqueous | Same As Above |
| G14030467-004 | Rimrock 33-4-6-2CH | 03/21/14 16:30 | 03/24/14 | Aqueous | Same As Above |
| G14030467-005 | Gaviota 35-12-1CH | 03/21/14 15:15 | 03/24/14 | Aqueous | Same As Above |
| G14030467-006 | Rosemary 31-3-16H | 03/22/14 9:00 | 03/24/14 | Oil | Bottom Sediment and Water<br>Crude Oil Preparation<br>Gravity, API<br>Gravity, Specific<br>Initial Boiling Point from Hempel Dist.<br>Hempel Distillation, Pressure<br>Hempel Distillation, Specific Gravities<br>Hempel Distillation, Volume %<br>Pour Point in Oil<br>Total Sulfur in Oils<br>Viscosity<br>Viscosity<br>Viscosity |
| G14030467-007 | Warren 17-1CH | 03/21/14 11:45 | 03/24/14 | Oil | Same As Above |
| G14030467-008 | Warren 17-1CH | 03/21/14 11:30 | 03/24/14 | Oil | Same As Above |
| G14030467-009 | Rimrock 33-4-6-2CH | 03/21/14 16:45 | 03/24/14 | Oil | Same As Above |
| G14030467-010 | Gaviota 35-12-1CH | 03/21/14 15:15 | 03/24/14 | Oil | Same As Above |

The analyses presented in this report were performed by Energy Laboratories, Inc., 400 W. Boxelder Rd., Gillette, WY 82718, unless otherwise noted.

As appropriate, any exceptions or problems with the analyses are noted in the Laboratory Analytical Report, the QA/QC Summary Report, or the Case Narrative.

The results as reported relate only to the item(s) submitted for testing.

# ANALYTICAL SUMMARY REPORT

If you have any questions regarding these tests results, please call.

Report Approved By:

CLIENT: Cirque Resources LP
Project: Not Indicated
Work Order: G14030467

Report Date: 04/10/14

# CASE NARRATIVE

Tests associated with analyst identified as ELI-B were subcontracted to Energy Laboratories, 1120 S. 27th St., Billings, MT, EPA Number MT00005.

Prep Comments for Sample G14030467-001B, Test PRP-FILT-W: The prep HoldTime was exceeded by 0.177 days.
Prep Comments for Sample G14030467-002B, Test PRP-FILT-W: The prep HoldTime was exceeded by 1.06 days.
Prep Comments for Sample G14030467-003B, Test PRP-FILT-W: The prep HoldTime was exceeded by 1.07 days.
Prep Comments for Sample G14030467-004B, Test PRP-FILT-W: The prep HoldTime was exceeded by 0.865 days.
Prep Comments for Sample G14030467-005B, Test PRP-FILT-W: The prep HoldTime was exceeded by 0.917 days.

It is recommended that filtering and preservation of the dissolved fraction be performed in the field at time of sample collection.

Thank you,

Alyson Degnan
Project Manager

# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| Client: | Cirque Resources LP | | |
| Project: | Not Indicated | Report Date: | 04/10/14 |
| Client Sample ID: | Rosemary 31-3-16H | Collection Date: | 03/22/14 09:00 |
| Location: | | Date Received: | 03/24/14 |
| Samp FRQ/Type: | | Matrix: | Aqueous |
| Lab ID: | G14030467-001 | Sampled By: | Myron Means |

| Analyses | Result | Units | RL | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|---|
| **MAJOR IONS, DISSOLVED** | | | | | | |
| Bicarbonate as HCO3 | 511 | mg/L | 5 | | A2320 B | 03/25/14 15:38 / blb |
| Carbonate as CO3 | ND | mg/L | 5 | | A2320 B | 03/25/14 15:38 / blb |
| Hydroxide as OH | ND | mg/L | 5 | | A2320 B | 03/25/14 15:38 / blb |
| Chloride | 26800 | mg/L | 100 | D | E300.0 | 03/25/14 18:23 / blb |
| Sulfate | 20 | mg/L | 10 | D | E300.0 | 04/10/14 02:07 / blb |
| Calcium | 695 | mg/L | 1 | | E200.7 | 04/08/14 12:05 / eli-b |
| Magnesium | 97 | mg/L | 4 | D | E200.7 | 04/08/14 12:05 / eli-b |
| Potassium | 93 | mg/L | 8 | D | E200.7 | 04/08/14 12:05 / eli-b |
| Sodium | 16300 | mg/L | 70 | D | E200.7 | 04/08/14 12:05 / eli-b |
| **METALS, DISSOLVED** | | | | | | |
| Barium | 54.0 | mg/L | 0.05 | | E200.7 | 03/26/14 13:23 / eli-b |
| Iron | 19.5 | mg/L | 0.4 | D | E200.7 | 03/26/14 13:23 / eli-b |
| Strontium | 124 | mg/L | 0.02 | D | E200.7 | 03/26/14 13:23 / eli-b |
| **METALS, TOTAL RECOVERABLE** | | | | | | |
| Barium | 62.8 | mg/L | 0.05 | | E200.7 | 03/27/14 20:32 / eli-b |
| Iron | 51.1 | mg/L | 0.4 | D | E200.7 | 03/27/14 20:32 / eli-b |
| Manganese | 0.568 | mg/L | 0.001 | | E200.8 | 03/27/14 23:05 / eli-b |
| Strontium | 134 | mg/L | 0.01 | | E200.8 | 03/27/14 23:05 / eli-b |
| **NON-METALS** | | | | | | |
| Alkalinity, Total as CaCO3 | 419 | mg/L | 5 | | A2320 B | 03/25/14 15:38 / blb |
| Conductivity @ 25 C | 63200 | umhos/cm | 10 | E | A2510 B | 03/24/14 17:07 / blb |
| pH | 6.56 | s.u. | 0.01 | H | A4500-H B | 03/24/14 17:07 / blb |
| Solids, Total Dissolved TDS @ 180 C | 45000 | mg/L | 1000 | | A2540 C | 03/25/14 08:46 / blb |
| Resistivity @ 68 F | 0.174 | ohm-m | | | E120.1 | 03/24/14 17:07 / tla |
| Solids, Total Dissolved - Calculated | 44200 | mg/L | 1 | | A1030 E | 04/10/14 10:06 / tla |
| **DATA QUALITY** | | | | | | |
| A/C Balance | -1.13 | % | | | A1030 E | 04/10/14 10:06 / tla |
| Anions | 770 | meq/L | | | A1030 E | 04/10/14 10:06 / tla |
| Cations | 753 | meq/L | | | A1030 E | 04/10/14 10:06 / tla |

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
E - Estimated value. Result exceeds the instrument upper quantitation limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| Client: | Cirque Resources LP | | |
| Project: | Not Indicated | Report Date: | 04/10/14 |
| Client Sample ID: | Warren 17-1CH | Collection Date: | 03/21/14 11:45 |
| Location: | | Date Received: | 03/24/14 |
| Samp FRQ/Type: | | Matrix: | Aqueous |
| Lab ID: | G14030467-002 | Sampled By: | Myron Means |

| Analyses | Result | Units | RL | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|---|
| **MAJOR IONS, DISSOLVED** | | | | | | |
| Bicarbonate as HCO3 | 474 | mg/L | 5 | | A2320 B | 04/03/14 14:02 / blb |
| Carbonate as CO3 | ND | mg/L | 5 | | A2320 B | 04/03/14 14:02 / blb |
| Hydroxide as OH | ND | mg/L | 5 | | A2320 B | 04/03/14 14:02 / blb |
| Chloride | 27300 | mg/L | 100 | D | E300.0 | 04/08/14 14:20 / blb |
| Sulfate | ND | mg/L | 10 | D | E300.0 | 03/26/14 12:45 / blb |
| Calcium | 681 | mg/L | 1 | | E200.7 | 04/08/14 12:09 / eli-b |
| Magnesium | 91 | mg/L | 4 | D | E200.7 | 04/08/14 12:09 / eli-b |
| Potassium | 70 | mg/L | 8 | D | E200.7 | 04/08/14 12:09 / eli-b |
| Sodium | 16800 | mg/L | 70 | D | E200.7 | 04/08/14 12:09 / eli-b |
| **METALS, DISSOLVED** | | | | | | |
| Barium | 68.5 | mg/L | 0.05 | | E200.7 | 03/26/14 13:27 / eli-b |
| Iron | 22.4 | mg/L | 0.4 | D | E200.7 | 03/26/14 13:27 / eli-b |
| Strontium | 136 | mg/L | 0.02 | D | E200.7 | 03/26/14 13:27 / eli-b |
| **METALS, TOTAL RECOVERABLE** | | | | | | |
| Barium | 81.7 | mg/L | 0.05 | | E200.7 | 03/27/14 20:36 / eli-b |
| Iron | 189 | mg/L | 0.4 | D | E200.7 | 03/27/14 20:36 / eli-b |
| Manganese | 1.62 | mg/L | 0.001 | | E200.8 | 03/27/14 23:11 / eli-b |
| Strontium | 150 | mg/L | 0.01 | | E200.8 | 03/27/14 23:11 / eli-b |
| **NON-METALS** | | | | | | |
| Alkalinity, Total as CaCO3 | 388 | mg/L | 5 | | A2320 B | 04/03/14 14:02 / blb |
| Conductivity @ 25 C | 64800 | umhos/cm | 10 | E | A2510 B | 03/24/14 17:13 / blb |
| pH | 6.33 | s.u. | 0.01 | H | A4500-H B | 03/24/14 17:13 / blb |
| Solids, Total Dissolved TDS @ 180 C | 46700 | mg/L | 1000 | | A2540 C | 03/25/14 08:47 / blb |
| Resistivity @ 68 F | 0.169 | ohm-m | | | E120.1 | 03/24/14 17:13 / tla |
| Solids, Total Dissolved - Calculated | 45200 | mg/L | 1 | | A1030 E | 04/10/14 08:38 / tla |
| **DATA QUALITY** | | | | | | |
| A/C Balance | -0.72 | % | | | A1030 E | 04/10/14 08:38 / tla |
| Anions | 783 | meq/L | | | A1030 E | 04/10/14 08:38 / tla |
| Cations | 772 | meq/L | | | A1030 E | 04/10/14 08:38 / tla |

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D - RL increased due to sample matrix.
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MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
E - Estimated value. Result exceeds the instrument upper quantitation limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| Client: | Cirque Resources LP | | |
| Project: | Not Indicated | Report Date: | 04/10/14 |
| Client Sample ID: | Dewey 7-9-1CH | Collection Date: | 03/21/14 11:30 |
| Location: | | Date Received: | 03/24/14 |
| Samp FRQ/Type: | | Matrix: | Aqueous |
| Lab ID: | G14030467-003 | Sampled By: | Myron Means |

| Analyses | Result | Units | RL | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|---|
| **MAJOR IONS, DISSOLVED** | | | | | | |
| Bicarbonate as HCO3 | 417 | mg/L | 5 | | A2320 B | 03/25/14 16:09 / blb |
| Carbonate as CO3 | ND | mg/L | 5 | | A2320 B | 03/25/14 16:09 / blb |
| Hydroxide as OH | ND | mg/L | 5 | | A2320 B | 03/25/14 16:09 / blb |
| Chloride | 33200 | mg/L | 100 | D | E300.0 | 03/25/14 18:54 / blb |
| Sulfate | ND | mg/L | 10 | D | E300.0 | 03/26/14 13:00 / blb |
| Calcium | 720 | mg/L | 1 | | E200.7 | 03/26/14 13:31 / eli-b |
| Magnesium | 102 | mg/L | 4 | D | E200.7 | 03/26/14 13:31 / eli-b |
| Potassium | 163 | mg/L | 8 | D | E200.7 | 03/26/14 13:31 / eli-b |
| Sodium | 19300 | mg/L | 70 | D | E200.7 | 03/26/14 13:31 / eli-b |
| **METALS, DISSOLVED** | | | | | | |
| Barium | 65.4 | mg/L | 0.05 | | E200.7 | 03/26/14 13:31 / eli-b |
| Iron | 0.7 | mg/L | 0.4 | D | E200.7 | 03/26/14 13:31 / eli-b |
| Strontium | 161 | mg/L | 0.02 | D | E200.7 | 03/26/14 13:31 / eli-b |
| **METALS, TOTAL RECOVERABLE** | | | | | | |
| Barium | 71.8 | mg/L | 0.05 | | E200.7 | 03/27/14 20:40 / eli-b |
| Iron | 40.3 | mg/L | 0.4 | D | E200.7 | 03/27/14 20:40 / eli-b |
| Manganese | 0.540 | mg/L | 0.001 | | E200.8 | 03/27/14 23:16 / eli-b |
| Strontium | 166 | mg/L | 0.01 | | E200.8 | 03/27/14 23:16 / eli-b |
| **NON-METALS** | | | | | | |
| Alkalinity, Total as CaCO3 | 342 | mg/L | 5 | | A2320 B | 03/25/14 16:09 / blb |
| Conductivity @ 25 C | 72700 | umhos/cm | 10 | E | A2510 B | 03/24/14 17:16 / blb |
| pH | 6.44 | s.u. | 0.01 | H | A4500-H B | 03/24/14 17:16 / blb |
| Solids, Total Dissolved TDS @ 180 C | 53600 | mg/L | 1000 | | A2540 C | 03/25/14 08:47 / blb |
| Resistivity @ 68 F | 0.151 | ohm-m | | | E120.1 | 03/24/14 17:16 / tla |
| Solids, Total Dissolved - Calculated | 53600 | mg/L | 1 | | A1030 E | 04/07/14 09:28 / tla |
| **DATA QUALITY** | | | | | | |
| A/C Balance | -3.31 | % | | | A1030 E | 04/07/14 09:28 / tla |
| Anions | 948 | meq/L | | | A1030 E | 04/07/14 09:28 / tla |
| Cations | 887 | meq/L | | | A1030 E | 04/07/14 09:28 / tla |

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MCL - Maximum contaminant level.
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# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| Client: | Cirque Resources LP | | |
| Project: | Not Indicated | Report Date: | 04/10/14 |
| Client Sample ID: | Rimrock 33-4-6-2CH | Collection Date: | 03/21/14 16:30 |
| Location: | | Date Received: | 03/24/14 |
| Samp FRQ/Type: | | Matrix: | Aqueous |
| Lab ID: | G14030467-004 | Sampled By: | Myron Means |

| Analyses | Result | Units | RL | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|---|
| **MAJOR IONS, DISSOLVED** | | | | | | |
| Bicarbonate as HCO3 | 698 | mg/L | 5 | | A2320 B | 03/25/14 16:16 / blb |
| Carbonate as CO3 | ND | mg/L | 5 | | A2320 B | 03/25/14 16:16 / blb |
| Hydroxide as OH | ND | mg/L | 5 | | A2320 B | 03/25/14 16:16 / blb |
| Chloride | 20400 | mg/L | 40 | D | E300.0 | 03/25/14 19:09 / blb |
| Sulfate | 22 | mg/L | 4 | D | E300.0 | 03/26/14 13:16 / blb |
| Calcium | 506 | mg/L | 1 | | E200.7 | 03/26/14 13:35 / eli-b |
| Magnesium | 65 | mg/L | 4 | D | E200.7 | 03/26/14 13:35 / eli-b |
| Potassium | 77 | mg/L | 8 | D | E200.7 | 03/26/14 13:35 / eli-b |
| Sodium | 13300 | mg/L | 70 | D | E200.7 | 03/26/14 13:35 / eli-b |
| **METALS, DISSOLVED** | | | | | | |
| Barium | 35.0 | mg/L | 0.05 | | E200.7 | 03/26/14 13:35 / eli-b |
| Iron | 16.5 | mg/L | 0.4 | D | E200.7 | 03/26/14 13:35 / eli-b |
| Strontium | 94.3 | mg/L | 0.02 | D | E200.7 | 03/26/14 13:35 / eli-b |
| **METALS, TOTAL RECOVERABLE** | | | | | | |
| Barium | 38.2 | mg/L | 0.05 | | E200.7 | 03/27/14 20:44 / eli-b |
| Iron | 85.2 | mg/L | 0.4 | D | E200.7 | 03/27/14 20:44 / eli-b |
| Manganese | 0.963 | mg/L | 0.001 | | E200.8 | 03/27/14 23:21 / eli-b |
| Strontium | 93.5 | mg/L | 0.01 | | E200.8 | 03/27/14 23:21 / eli-b |
| **NON-METALS** | | | | | | |
| Alkalinity, Total as CaCO3 | 572 | mg/L | 5 | | A2320 B | 03/25/14 16:16 / blb |
| Conductivity @ 25 C | 51800 | umhos/cm | 10 | E | A2510 B | 03/24/14 17:19 / blb |
| pH | 6.65 | s.u. | 0.01 | H | A4500-H B | 03/24/14 17:19 / blb |
| Solids, Total Dissolved TDS @ 180 C | 36300 | mg/L | 1000 | | A2540 C | 03/25/14 08:47 / blb |
| Resistivity @ 68 F | 0.212 | ohm-m | | | E120.1 | 03/24/14 17:19 / tla |
| Solids, Total Dissolved - Calculated | 34700 | mg/L | 1 | | A1030 E | 04/07/14 09:28 / tla |
| **DATA QUALITY** | | | | | | |
| A/C Balance | 1.77 | % | | | A1030 E | 04/07/14 09:28 / tla |
| Anions | 590 | meq/L | | | A1030 E | 04/07/14 09:28 / tla |
| Cations | 612 | meq/L | | | A1030 E | 04/07/14 09:28 / tla |

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H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
E - Estimated value. Result exceeds the instrument upper quantitation limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| Client: | Cirque Resources LP | | |
| Project: | Not Indicated | Report Date: | 04/10/14 |
| Client Sample ID: | Gaviota 35-12-1CH | Collection Date: | 03/21/14 15:15 |
| Location: | | Date Received: | 03/24/14 |
| Samp FRQ/Type: | | Matrix: | Aqueous |
| Lab ID: | G14030467-005 | Sampled By: | Myron Means |

| Analyses | Result | Units | RL | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|---|
| **MAJOR IONS, DISSOLVED** | | | | | | |
| Bicarbonate as HCO3 | 496 | mg/L | 5 | | A2320 B | 03/25/14 16:23 / blb |
| Carbonate as CO3 | ND | mg/L | 5 | | A2320 B | 03/25/14 16:23 / blb |
| Hydroxide as OH | ND | mg/L | 5 | | A2320 B | 03/25/14 16:23 / blb |
| Chloride | 32100 | mg/L | 100 | D | E300.0 | 03/25/14 19:24 / blb |
| Sulfate | 12 | mg/L | 10 | D | E300.0 | 03/26/14 13:31 / blb |
| Calcium | 625 | mg/L | 1 | | E200.7 | 03/26/14 13:39 / eli-b |
| Magnesium | 89 | mg/L | 4 | D | E200.7 | 03/26/14 13:39 / eli-b |
| Potassium | 123 | mg/L | 8 | D | E200.7 | 03/26/14 13:39 / eli-b |
| Sodium | 19000 | mg/L | 70 | D | E200.7 | 03/26/14 13:39 / eli-b |
| **METALS, DISSOLVED** | | | | | | |
| Barium | 68.4 | mg/L | 0.05 | | E200.7 | 03/26/14 13:39 / eli-b |
| Iron | 11.8 | mg/L | 0.4 | D | E200.7 | 03/26/14 13:39 / eli-b |
| Strontium | 148 | mg/L | 0.02 | D | E200.7 | 03/26/14 13:39 / eli-b |
| **METALS, TOTAL RECOVERABLE** | | | | | | |
| Barium | 77.4 | mg/L | 0.05 | | E200.7 | 03/27/14 20:55 / eli-b |
| Iron | 52.5 | mg/L | 0.4 | D | E200.7 | 03/27/14 20:55 / eli-b |
| Manganese | 0.506 | mg/L | 0.001 | | E200.8 | 03/27/14 23:27 / eli-b |
| Strontium | 155 | mg/L | 0.01 | | E200.8 | 03/27/14 23:27 / eli-b |
| **NON-METALS** | | | | | | |
| Alkalinity, Total as CaCO3 | 407 | mg/L | 5 | | A2320 B | 03/25/14 16:23 / blb |
| Conductivity @ 25 C | 72900 | umhos/cm | 10 | E | A2510 B | 03/24/14 17:22 / blb |
| pH | 6.53 | s.u. | 0.01 | H | A4500-H B | 03/24/14 17:22 / blb |
| Solids, Total Dissolved TDS @ 180 C | 54500 | mg/L | 1000 | | A2540 C | 03/25/14 08:47 / blb |
| Resistivity @ 68 F | 0.151 | ohm-m | | | E120.1 | 03/24/14 17:22 / tla |
| Solids, Total Dissolved - Calculated | 52200 | mg/L | 1 | | A1030 E | 04/07/14 09:29 / tla |
| **DATA QUALITY** | | | | | | |
| A/C Balance | -2.95 | % | | | A1030 E | 04/07/14 09:29 / tla |
| Anions | 920 | meq/L | | | A1030 E | 04/07/14 09:29 / tla |
| Cations | 867 | meq/L | | | A1030 E | 04/07/14 09:29 / tla |

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
E - Estimated value. Result exceeds the instrument upper quantitation limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| Client: | Cirque Resources LP | | |
| Project: | Not Indicated | Report Date: | 04/10/14 |
| Client Sample ID: | Rosemary 31-3-16H | Collection Date: | 03/22/14 09:00 |
| Location: | | Date Received: | 03/24/14 |
| Samp FRQ/Type: | | Matrix: | Oil |
| Lab ID: | G14030467-006 | Sampled By: | Myron Means |

| Analyses | Result | Units | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|
| **OIL CHARACTERISTICS** | | | | | |
| Bottom Sediment and Water | 18 | Vol % | | D1796 | 03/24/14 15:30 / mav |
| Gravity, API @ 60 F | 35.6 | degrees | | D287 | 03/26/14 08:45 / mav |
| Specific Gravity @ 60 F | 0.847 | unitless | | D1298 | 03/26/14 08:45 / mav |
| Pour Point | 30 | °F | | D97 | 03/26/14 12:30 / mav |
| **ABSOLUTE VISCOSITY** | | | | | |
| Absolute Viscosity @ 100 F | 4.97 | cP | | D445 | 03/26/14 13:30 / mav |
| Absolute Viscosity @ 120 F | 3.78 | cP | | D445 | 03/26/14 15:00 / mav |
| **KINEMATIC VISCOSITY** | | | | | |
| Kinematic Viscosity @ 100 F | 5.97 | cSt | | D445 | 03/26/14 13:30 / mav |
| Kinematic Viscosity @ 120 F | 4.58 | cSt | | D445 | 03/26/14 15:00 / mav |
| **SAYBOLT UNIVERSAL VISCOSITY** | | | | | |
| Saybolt Universal Viscosity @ 100 F | 45.5 | s | | D2161 | 03/26/14 13:30 / mav |
| Saybolt Universal Viscosity @ 120 F | 41.1 | s | | D2161 | 03/26/14 15:00 / mav |
| **HEMPEL DISTILLATION** | | | | | |
| Barometric Pressure | 25.06 | in. Hg | | D285 | 03/26/14 11:12 / djb |
| Initial Boiling Point | 80 | °F | | D285 | 03/26/14 11:12 / djb |
| Gasoline (392 F), SG | 0.745 | unitless | | D285 | 03/26/14 11:12 / djb |
| Kerosene (500 F), SG | 0.787 | unitless | | D285 | 03/26/14 11:12 / djb |
| Reduced Crude, SG | 0.914 | unitless | | D285 | 03/26/14 11:12 / djb |
| Gasoline (392 F), Volume | 29.2 | % | | D285 | 03/26/14 11:12 / djb |
| Kerosene (500 F), Volume | 11.3 | % | | D285 | 03/26/14 11:12 / djb |
| Reduced Crude, Volume | 57.4 | % | | D285 | 03/26/14 11:12 / djb |
| Loss, Volume | 2.2 | % | | D285 | 03/26/14 11:12 / djb |
| **SULFUR IN OILS** | | | | | |
| Sulfur, Total | 0.25 | wt% | | D1552 | 04/04/14 11:33 / eli-b |

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| Client: | Cirque Resources LP | | |
| Project: | Not Indicated | Report Date: | 04/10/14 |
| Client Sample ID: | Warren 17-1CH | Collection Date: | 03/21/14 11:45 |
| Location: | | Date Received: | 03/24/14 |
| Samp FRQ/Type: | | Matrix: | Oil |
| Lab ID: | G14030467-007 | Sampled By: | Myron Means |

| Analyses | Result | Units | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|
| **OIL CHARACTERISTICS** | | | | | |
| Bottom Sediment and Water | 70 | Vol % | | D1796 | 03/24/14 15:30 / mav |
| Gravity, API @ 60 F | 34.9 | degrees | | D287 | 03/26/14 09:15 / mav |
| Specific Gravity @ 60 F | 0.850 | unitless | | D1298 | 03/26/14 09:15 / mav |
| Pour Point | <-50 | °F | | D97 | 03/27/14 16:00 / mav |
| **ABSOLUTE VISCOSITY** | | | | | |
| Absolute Viscosity @ 100 F | 5.56 | cP | | D445 | 03/26/14 14:15 / mav |
| Absolute Viscosity @ 120 F | 4.28 | cP | | D445 | 03/26/14 14:45 / mav |
| **KINEMATIC VISCOSITY** | | | | | |
| Kinematic Viscosity @ 100 F | 6.65 | cSt | | D445 | 03/26/14 14:15 / mav |
| Kinematic Viscosity @ 120 F | 5.16 | cSt | | D445 | 03/26/14 14:45 / mav |
| **SAYBOLT UNIVERSAL VISCOSITY** | | | | | |
| Saybolt Universal Viscosity @ 100 F | 47.7 | s | | D2161 | 03/26/14 14:15 / mav |
| Saybolt Universal Viscosity @ 120 F | 42.9 | s | | D2161 | 03/26/14 14:45 / mav |
| **HEMPEL DISTILLATION** | | | | | |
| Barometric Pressure | 26.05 | in. Hg | | D285 | 03/26/14 15:58 / djb |
| Initial Boiling Point | 80 | °F | | D285 | 03/26/14 15:58 / djb |
| Gasoline (392 F), SG | 0.740 | unitless | | D285 | 03/26/14 15:58 / djb |
| Kerosene (500 F), SG | 0.796 | unitless | | D285 | 03/26/14 15:58 / djb |
| Reduced Crude, SG | 0.919 | unitless | | D285 | 03/26/14 15:58 / djb |
| Gasoline (392 F), Volume | 29.7 | % | | D285 | 03/26/14 15:58 / djb |
| Kerosene (500 F), Volume | 10.8 | % | | D285 | 03/26/14 15:58 / djb |
| Reduced Crude, Volume | 58.2 | % | | D285 | 03/26/14 15:58 / djb |
| Loss, Volume | 1.4 | % | | D285 | 03/26/14 15:58 / djb |
| **SULFUR IN OILS** | | | | | |
| Sulfur, Total | 0.22 | wt% | | D1552 | 04/04/14 11:33 / eli-b |

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| Client: | Cirque Resources LP | | |
| Project: | Not Indicated | Report Date: | 04/10/14 |
| Client Sample ID: | Warren 17-1CH | Collection Date: | 03/21/14 11:30 |
| Location: | | Date Received: | 03/24/14 |
| Samp FRQ/Type: | | Matrix: | Oil |
| Lab ID: | G14030467-008 | Sampled By: | Myron Means |

| Analyses | Result | Units | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|
| **OIL CHARACTERISTICS** | | | | | |
| Bottom Sediment and Water | 22 | Vol % | | D1796 | 03/24/14 15:45 / mav |
| Gravity, API @ 60 F | 37.0 | degrees | | D287 | 03/26/14 09:30 / mav |
| Specific Gravity @ 60 F | 0.840 | unitless | | D1298 | 03/26/14 09:30 / mav |
| Pour Point | <-50 | °F | | D97 | 03/27/14 16:30 / mav |
| **ABSOLUTE VISCOSITY** | | | | | |
| Absolute Viscosity @ 100 F | 4.18 | cP | | D445 | 03/26/14 14:15 / mav |
| Absolute Viscosity @ 120 F | 3.34 | cP | | D445 | 03/26/14 14:45 / mav |
| **KINEMATIC VISCOSITY** | | | | | |
| Kinematic Viscosity @ 100 F | 5.06 | cSt | | D445 | 03/26/14 14:15 / mav |
| Kinematic Viscosity @ 120 F | 4.08 | cSt | | D445 | 03/26/14 14:45 / mav |
| **SAYBOLT UNIVERSAL VISCOSITY** | | | | | |
| Saybolt Universal Viscosity @ 100 F | 42.6 | s | | D2161 | 03/26/14 14:15 / mav |
| Saybolt Universal Viscosity @ 120 F | 39.5 | s | | D2161 | 03/26/14 14:45 / mav |
| **HEMPEL DISTILLATION** | | | | | |
| Barometric Pressure | 26.22 | in. Hg | | D285 | 04/01/14 14:00 / mav |
| Initial Boiling Point | 74 | °F | | D285 | 04/01/14 14:00 / mav |
| Gasoline (392 F), SG | 0.728 | unitless | | D285 | 04/01/14 14:00 / mav |
| Kerosene (500 F), SG | 0.796 | unitless | | D285 | 04/01/14 14:00 / mav |
| Reduced Crude, SG | 0.916 | unitless | | D285 | 04/01/14 14:00 / mav |
| Gasoline (392 F), Volume | 31.1 | % | | D285 | 04/01/14 14:00 / mav |
| Kerosene (500 F), Volume | 10.2 | % | | D285 | 04/01/14 14:00 / mav |
| Reduced Crude, Volume | 55.7 | % | | D285 | 04/01/14 14:00 / mav |
| Loss, Volume | 3.0 | % | | D285 | 04/01/14 14:00 / mav |
| **SULFUR IN OILS** | | | | | |
| Sulfur, Total | 0.26 | wt% | | D1552 | 04/04/14 11:33 / eli-b |

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| Client: | Cirque Resources LP | | |
| Project: | Not Indicated | Report Date: | 04/10/14 |
| Client Sample ID: | Rimrock 33-4-6-2CH | Collection Date: | 03/21/14 16:45 |
| Location: | | Date Received: | 03/24/14 |
| Samp FRQ/Type: | | Matrix: | Oil |
| Lab ID: | G14030467-009 | Sampled By: | Myron Means |

| Analyses | Result | Units | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|
| **OIL CHARACTERISTICS** | | | | | |
| Bottom Sediment and Water | 44 | Vol % | | D1796 | 03/24/14 15:45 / mav |
| Gravity, API @ 60 F | 36.2 | degrees | | D287 | 03/26/14 10:00 / mav |
| Specific Gravity @ 60 F | 0.844 | unitless | | D1298 | 03/26/14 10:00 / mav |
| Pour Point | 20 | °F | | D97 | 03/26/14 16:15 / mav |
| **ABSOLUTE VISCOSITY** | | | | | |
| Absolute Viscosity @ 100 F | 4.44 | cP | | D445 | 03/26/14 14:15 / mav |
| Absolute Viscosity @ 120 F | 3.34 | cP | | D445 | 03/26/14 14:45 / mav |
| **KINEMATIC VISCOSITY** | | | | | |
| Kinematic Viscosity @ 100 F | 5.36 | cSt | | D445 | 03/26/14 14:15 / mav |
| Kinematic Viscosity @ 120 F | 4.06 | cSt | | D445 | 03/26/14 14:45 / mav |
| **SAYBOLT UNIVERSAL VISCOSITY** | | | | | |
| Saybolt Universal Viscosity @ 100 F | 43.5 | s | | D2161 | 03/26/14 14:15 / mav |
| Saybolt Universal Viscosity @ 120 F | 39.4 | s | | D2161 | 03/26/14 14:45 / mav |
| **HEMPEL DISTILLATION** | | | | | |
| Barometric Pressure | 26.22 | in. Hg | | D285 | 04/01/14 14:45 / mav |
| Initial Boiling Point | 76 | °F | | D285 | 04/01/14 14:45 / mav |
| Gasoline (392 F), SG | 0.730 | unitless | | D285 | 04/01/14 14:45 / mav |
| Kerosene (500 F), SG | 0.816 | unitless | | D285 | 04/01/14 14:45 / mav |
| Reduced Crude, SG | 0.919 | unitless | | D285 | 04/01/14 14:45 / mav |
| Gasoline (392 F), Volume | 32.1 | % | | D285 | 04/01/14 14:45 / mav |
| Kerosene (500 F), Volume | 11.2 | % | | D285 | 04/01/14 14:45 / mav |
| Reduced Crude, Volume | 55.3 | % | | D285 | 04/01/14 14:45 / mav |
| Loss, Volume | 1.5 | % | | D285 | 04/01/14 14:45 / mav |
| **SULFUR IN OILS** | | | | | |
| Sulfur, Total | 0.22 | wt% | | D1552 | 04/04/14 11:33 / eli-b |

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

# LABORATORY ANALYTICAL REPORT

Prepared by Gillette, WY Branch

| | | | |
|---|---|---|---|
| Client: | Cirque Resources LP | | |
| Project: | Not Indicated | Report Date: | 04/10/14 |
| Client Sample ID: | Gaviota 35-12-1CH | Collection Date: | 03/21/14 15:15 |
| Location: | | Date Received: | 03/24/14 |
| Samp FRQ/Type: | | Matrix: | Oil |
| Lab ID: | G14030467-010 | Sampled By: | Myron Means |

| Analyses | Result | Units | Qualifier | Method | Analysis Date / By |
|---|---|---|---|---|---|
| **OIL CHARACTERISTICS** | | | | | |
| Bottom Sediment and Water | 10 | Vol % | | D1796 | 03/24/14 15:40 / mav |
| Gravity, API @ 60 F | 35.9 | degrees | | D287 | 03/26/14 10:30 / mav |
| Specific Gravity @ 60 F | 0.845 | unitless | | D1298 | 03/26/14 10:30 / mav |
| Pour Point | 0 | °F | | D97 | 03/26/14 16:15 / mav |
| **ABSOLUTE VISCOSITY** | | | | | |
| Absolute Viscosity @ 100 F | 4.76 | cP | | D445 | 03/26/14 14:15 / mav |
| Absolute Viscosity @ 120 F | 3.70 | cP | | D445 | 03/26/14 14:45 / mav |
| **KINEMATIC VISCOSITY** | | | | | |
| Kinematic Viscosity @ 100 F | 5.73 | cSt | | D445 | 03/26/14 14:15 / mav |
| Kinematic Viscosity @ 120 F | 4.49 | cSt | | D445 | 03/26/14 14:45 / mav |
| **SAYBOLT UNIVERSAL VISCOSITY** | | | | | |
| Saybolt Universal Viscosity @ 100 F | 44.7 | s | | D2161 | 03/26/14 14:15 / mav |
| Saybolt Universal Viscosity @ 120 F | 40.8 | s | | D2161 | 03/26/14 14:45 / mav |
| **HEMPEL DISTILLATION** | | | | | |
| Barometric Pressure | 26.22 | in. Hg | | D285 | 04/01/14 15:15 / mav |
| Initial Boiling Point | 76 | °F | | D285 | 04/01/14 15:15 / mav |
| Gasoline (392 F), SG | 0.722 | unitless | | D285 | 04/01/14 15:15 / mav |
| Kerosene (500 F), SG | 0.778 | unitless | | D285 | 04/01/14 15:15 / mav |
| Reduced Crude, SG | 0.927 | unitless | | D285 | 04/01/14 15:15 / mav |
| Gasoline (392 F), Volume | 29.4 | % | | D285 | 04/01/14 15:15 / mav |
| Kerosene (500 F), Volume | 12.4 | % | | D285 | 04/01/14 15:15 / mav |
| Reduced Crude, Volume | 56.8 | % | | D285 | 04/01/14 15:15 / mav |
| Loss, Volume | 1.3 | % | | D285 | 04/01/14 15:15 / mav |
| **SULFUR IN OILS** | | | | | |
| Sulfur, Total | 0.22 | wt% | | D1552 | 04/04/14 11:33 / eli-b |

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

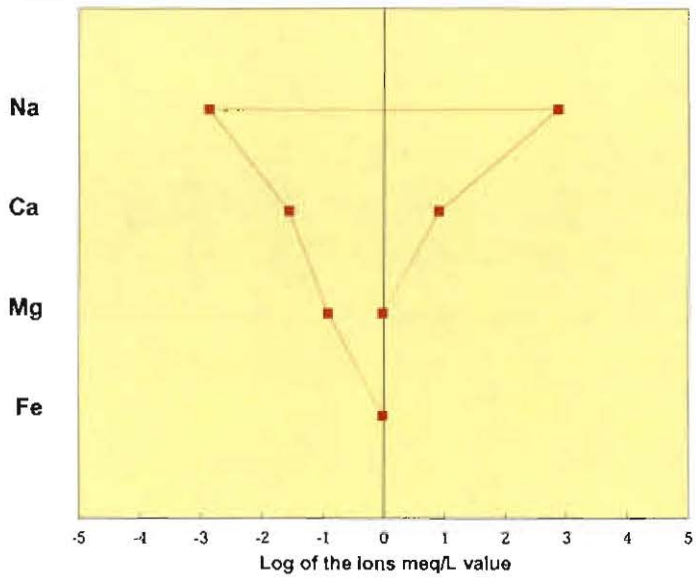
# LABORATORY ANALYTICAL REPORT

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Date Received: | 3/24/2014 |
| Location: | NOT GIVEN | Collection Date: | 3/22/2014 |
| Laboratory ID: | G14030467-001 | Matrix: | Water |
| Sample ID: | Rosemary 31-3-16H | | |

| CATIONS | mg/L | meq/L | ANIONS | mg/L | meq/L |
|---|---|---|---|---|---|
| Calcium | 695 | 34.68 | Bicarbonate | 511 | 8.38 |
| Magnesium | 97 | 7.99 | Carbonate | <1 | <0.03 |
| Potassium | 93 | 2.37 | Hydroxide | <1 | <0.06 |
| Sodium | 16,269 | 707.66 | Chloride | 26,818 | 756.46 |
| Iron, Dissolved | 19.51 | 0.70 | Sulfate | 20 | 0.42 |
| Barium, Dissolved | 54.03 | 0.79 | | | |
| Strontium, Dissolved | 124.02 | 2.83 | | | |
| **SUM +** | **17,351** | **757.02** | **SUM -** | **27,350** | **765.26** |

| Solids | | | Sample Conditions | | |
|---|---|---|---|---|---|
| Total Dissolved Solids, Calc | 44,200 | mg/L | Temperature, °F | 68 °F | |
| Total Solids, NaCl equivalents | 43,444 | mg/L | pH, s.u. | 6.56 s.u. | H |
| Chloride as NaCl | 44,209 | mg/L | Accuracy | 0.70 Sigma | |
| NaCl % of Total Dissolved Solids | 93.6 | % | Cation/Anion Balance | -0.55 % | |
| **Other Properties** | | | | | |
| Calcium Hardness as $CaCO_3$ | 1,735 | mg/L | Ionic Strength | 0.785 µ | |
| Magnesium Hardness as $CaCO_3$ | 400 | mg/L | Specific Gravity, Calc. | 1.029 g/cc | |
| Total Hardness as $CaCO_3$ | 2,135 | mg/L | Resistivity, 68°F | 0.16 ohm meter | E |
| **Microbiological** | | | **Scaling Conditions** | | |
| Sulfate Reducing Bacteria | NA | col/mL | CaCO3: Yes | CaSO4: No | |
| | | | BaSO4: Yes | SrSO4: No | |

**Water Analysis Pattern**




**Probable Mineral Residue, Dry**

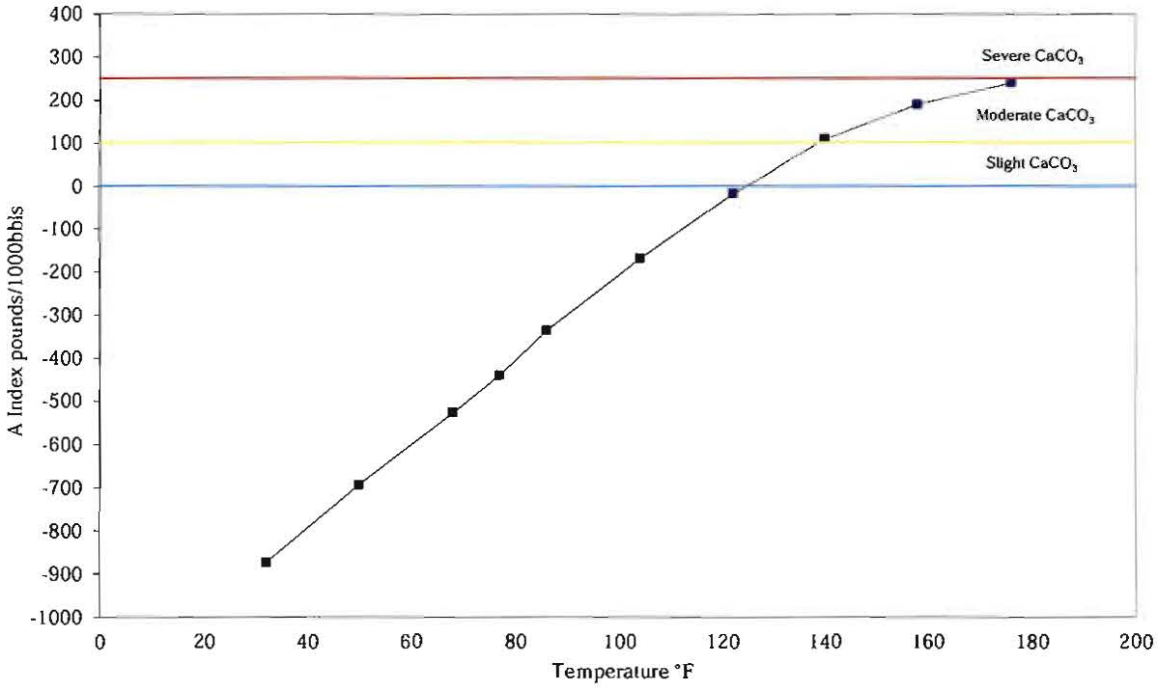
| Compound | mg/L |
|---|---|
| NaCl | 41,358 |
| CaCl2 | 1,459 |
| CaCO3 | 419 |
| MgCl2 | 380 |
| KCl | 177 |
| BaSO4 | 49 |
| Na2SO4 | 0 |
| CaSO4 | 0 |
| MgSO4 | 0 |
| SrSO4 | 0 |
| NaHCO3 | 0 |
| MgCO3 | 0 |

E - Estimated value. Result exceeds the instrument upper quantitation limit, Therefore Schlumberger Gen-9 Value Appears.
H - Analysis performed past recommended holding time.
NA - Not Analyzed

# STIFF - DAVIS REPORT
## Calcium Carbonate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/22/2014 |
| Laboratory ID: | G14030467-001 | Date Received: | 3/24/2014 |
| Sample ID: | Rosemary 31-3-16H | Matrix: | Water |

| Temperature | | Stiff-Davis | Aggressivity |
|---|---|---|---|
| C | F | Index | Index |
| 0 | 32 | -0.99 | -875 |
| 10 | 50 | -0.86 | -694 |
| 20 | 68 | -0.72 | -527 |
| 25 | 77 | -0.64 | -440 |
| 30 | 86 | -0.53 | -336 |
| 40 | 104 | -0.31 | -169 |
| 50 | 122 | -0.04 | -18 |
| 60 | 140 | 0.28 | 109 |
| 70 | 158 | 0.61 | 189 |
| 80 | 176 | 0.95 | 240 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.56 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.785 μ | Downhole temperature : | 68 °F |

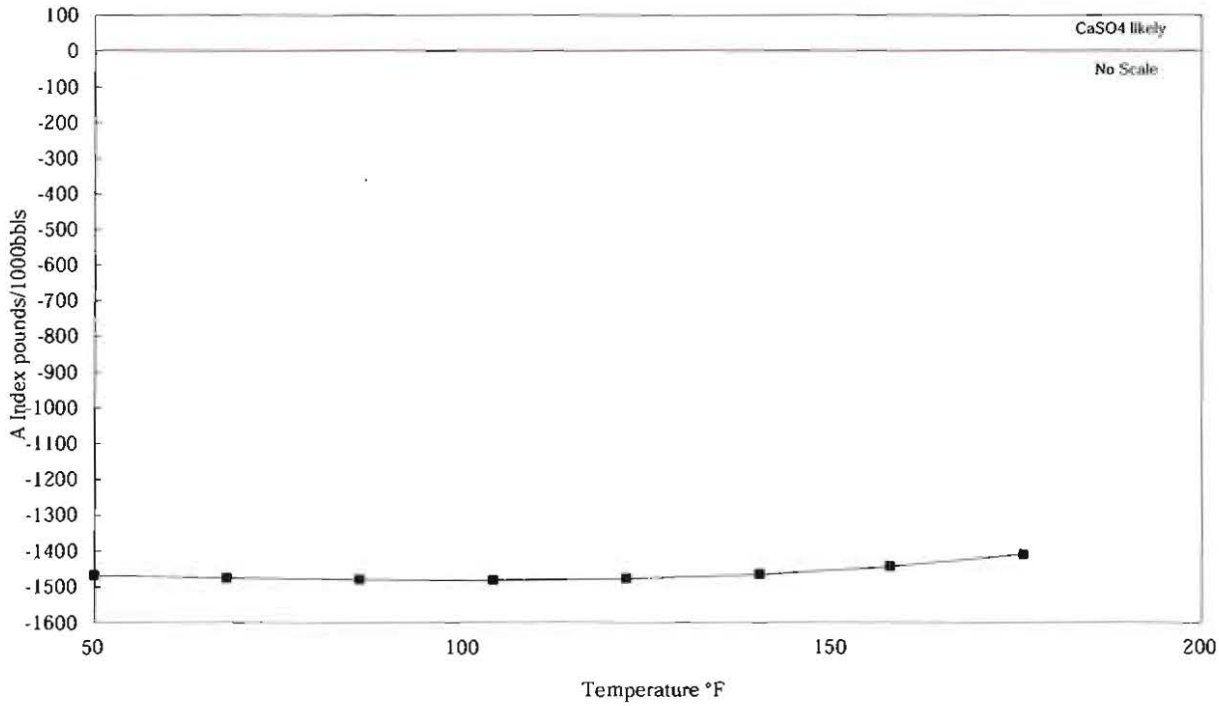
| NOTE: Stiff Davis Index | NOTE: A Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index > 0 - 100 Slight scaling. |
| 0 Saturation point, scale unlikely. | A Index > 100 - 250 Moderate scaling. |
| + Supersaturation, scaling condition. | A Index > 250 + Severe scaling. |

04/10/14

# Skillman Method
## Calcium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/22/2014 |
| Laboratory ID: | G14030467-001 | Date Received: | 3/24/2014 |
| Sample ID: | Rosemary 31-3-16H | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 10 | 50 | 0.42 | - | 62.03 | = | -61.61 | -1468 |
| 20 | 68 | 0.42 | - | 62.32 | = | -61.90 | -1475 |
| 30 | 86 | 0.42 | - | 62.55 | = | -62.13 | -1481 |
| 40 | 104 | 0.42 | - | 62.61 | = | -62.19 | -1482 |
| 50 | 122 | 0.42 | - | 62.44 | = | -62.02 | -1478 |
| 60 | 140 | 0.42 | - | 61.93 | = | -61.51 | -1466 |
| 70 | 158 | 0.42 | - | 60.99 | = | -60.57 | -1444 |
| 80 | 176 | 0.42 | - | 59.55 | = | -59.13 | -1410 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.56 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.785 µ | Downhole temperature : | 68 °F |

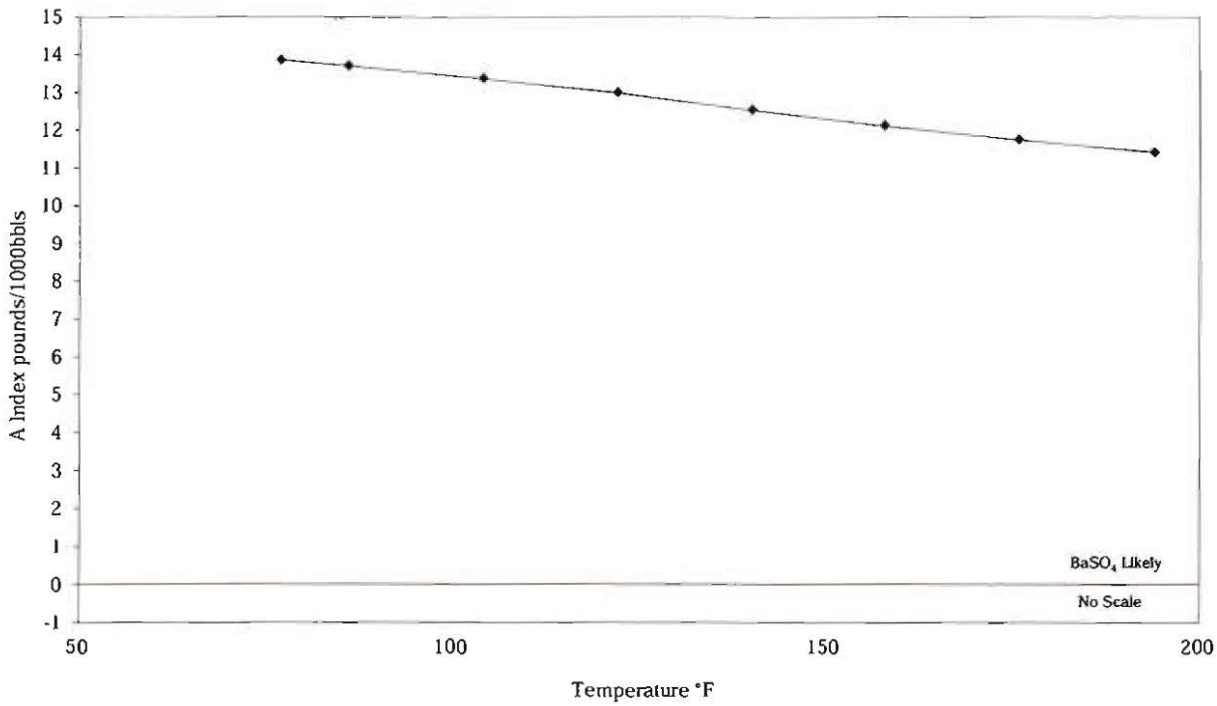
| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation positive. |
| + Supersaturation, scaling condition. | |

04/10/14

# Skillman Method
## Barium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/22/2014 |
| Laboratory ID: | G14030467-001 | Date Received: | 3/24/2014 |
| Sample ID: | Rosemary 31-3-16H | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 25 | 77 | 0.42000 | - | 0.07794 | = | 0.34206 | 13.861 |
| 30 | 86 | 0.42000 | - | 0.08172 | = | 0.33828 | 13.706 |
| 40 | 104 | 0.42000 | - | 0.09005 | = | 0.32995 | 13.366 |
| 50 | 122 | 0.42000 | - | 0.09904 | = | 0.32096 | 12.998 |
| 60 | 140 | 0.42000 | - | 0.11034 | = | 0.30966 | 12.536 |
| 70 | 158 | 0.42000 | - | 0.12042 | = | 0.29958 | 12.125 |
| 80 | 176 | 0.42000 | - | 0.12939 | = | 0.29061 | 11.758 |
| 90 | 194 | 0.42000 | - | 0.13761 | = | 0.28239 | 11.422 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.56 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.785 μ | Downhole temperature : | 68 °F |

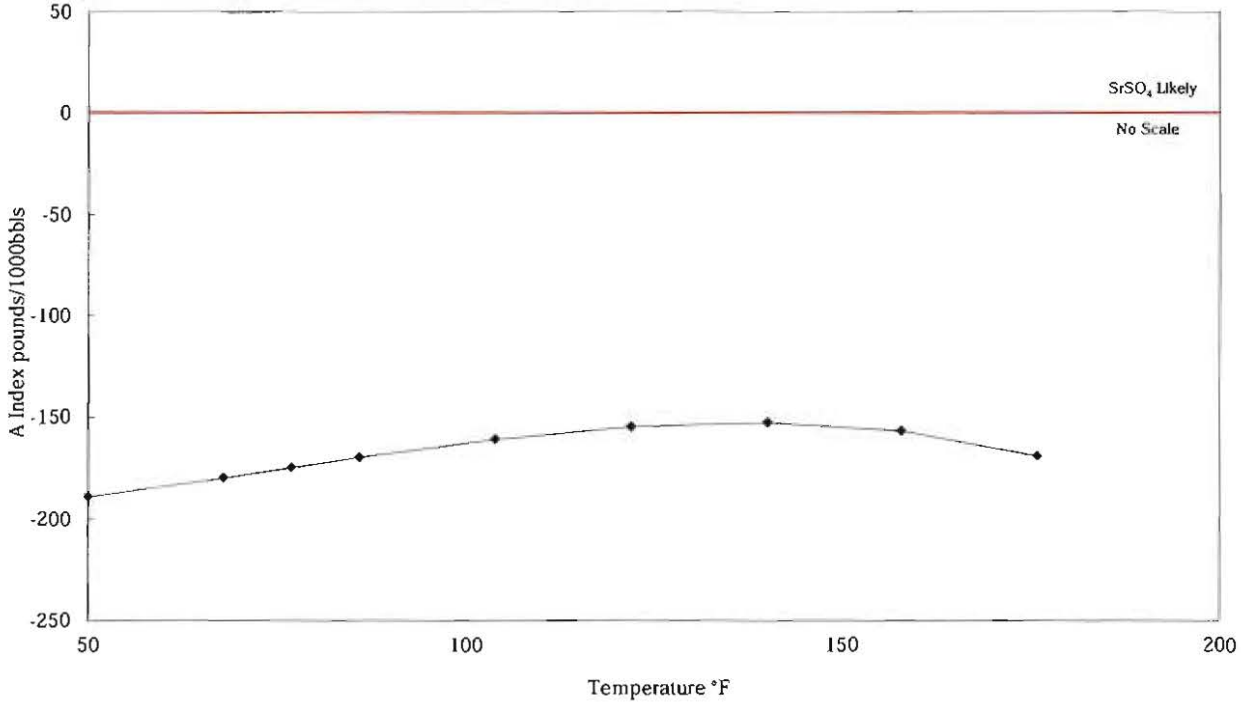
| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation could occur. |
| + Supersaturation, scaling condition. | |

04/10/14

# Skillman Method
## Strontium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/22/2014 |
| Laboratory ID: | G14030467-001 | Date Received: | 3/24/2014 |
| Sample ID: | Rosemary 31-3-16H | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 10 | 50 | 0.42 | - | 6.30 | = | -5.88 | -189.06 |
| 20 | 68 | 0.42 | - | 6.01 | = | -5.59 | -179.95 |
| 25 | 77 | 0.42 | - | 5.86 | = | -5.44 | -174.98 |
| 30 | 86 | 0.42 | - | 5.70 | = | -5.28 | -169.91 |
| 40 | 104 | 0.42 | - | 5.42 | = | -5.00 | -160.94 |
| 50 | 122 | 0.42 | - | 5.23 | = | -4.81 | -154.73 |
| 60 | 140 | 0.42 | - | 5.17 | = | -4.75 | -152.81 |
| 70 | 158 | 0.42 | - | 5.29 | = | -4.87 | -156.85 |
| 80 | 176 | 0.42 | - | 5.68 | = | -5.26 | -169.16 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.56 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.785 μ | Downhole temperature : | 68 °F |

| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation could occur. |
| + Supersaturation, scaling condition. | |

04/10/14

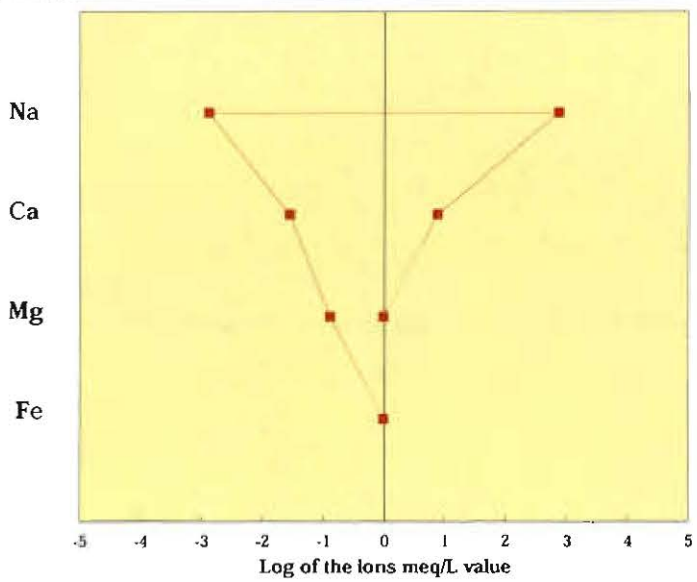
# LABORATORY ANALYTICAL REPORT

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Date Received: | 3/24/2014 |
| Location: | NOT GIVEN | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-002 | Matrix: | Water |
| Sample ID: | Warren 17-1CH | | |

| CATIONS | mg/L | meq/L | ANIONS | mg/L | meq/L |
|---|---|---|---|---|---|
| Calcium | 681 | 34.00 | Bicarbonate | 474 | 7.77 |
| Magnesium | 91 | 7.48 | Carbonate | <1 | <0.03 |
| Potassium | 70 | 1.79 | Hydroxide | <1 | <0.06 |
| Sodium | 16,755 | 728.80 | Chloride | 27,323 | 770.68 |
| Iron, Dissolved | 22.41 | 0.80 | Sulfate | <1 | <0.02 |
| Barium, Dissolved | 68.52 | 1.00 | | | |
| Strontium, Dissolved | 136.08 | 3.11 | | | |
| **SUM +** | **17,824** | **776.98** | **SUM -** | **27,797** | **778.45** |

| Solids | | | Sample Conditions | | |
|---|---|---|---|---|---|
| Total Dissolved Solids, Calc | 45,200 | mg/L | Temperature, °F | 68 °F | |
| Total Solids, NaCl equivalents | 44,415 | mg/L | pH, s.u. | 6.33 s.u. | H |
| Chloride as NaCl | 45,040 | mg/L | Accuracy | 0.12 Sigma | |
| NaCl % of Total Dissolved Solids | 94.2 | % | Cation/Anion Balance | -0.10 % | |
| **Other Properties** | | | | | |
| Calcium Hardness as $CaCO_3$ | 1,702 | mg/L | Ionic Strength | 0.801 µ | |
| Magnesium Hardness as $CaCO_3$ | 374 | mg/L | Specific Gravity, Calc. | 1.030 g/cc | |
| Total Hardness as $CaCO_3$ | 2,076 | mg/L | Resistivity, 68°F | 0.16 ohm meter | E |
| **Microbiological** | | | **Scaling Conditions** | | |
| Sulfate Reducing Bacteria | NA | col/mL | CaCO3: Yes | CaSO4: No | |
| | | | BaSO4: No | SrSO4: No | |

**Water Analysis Pattern**




**Probable Mineral Residue, Dry**

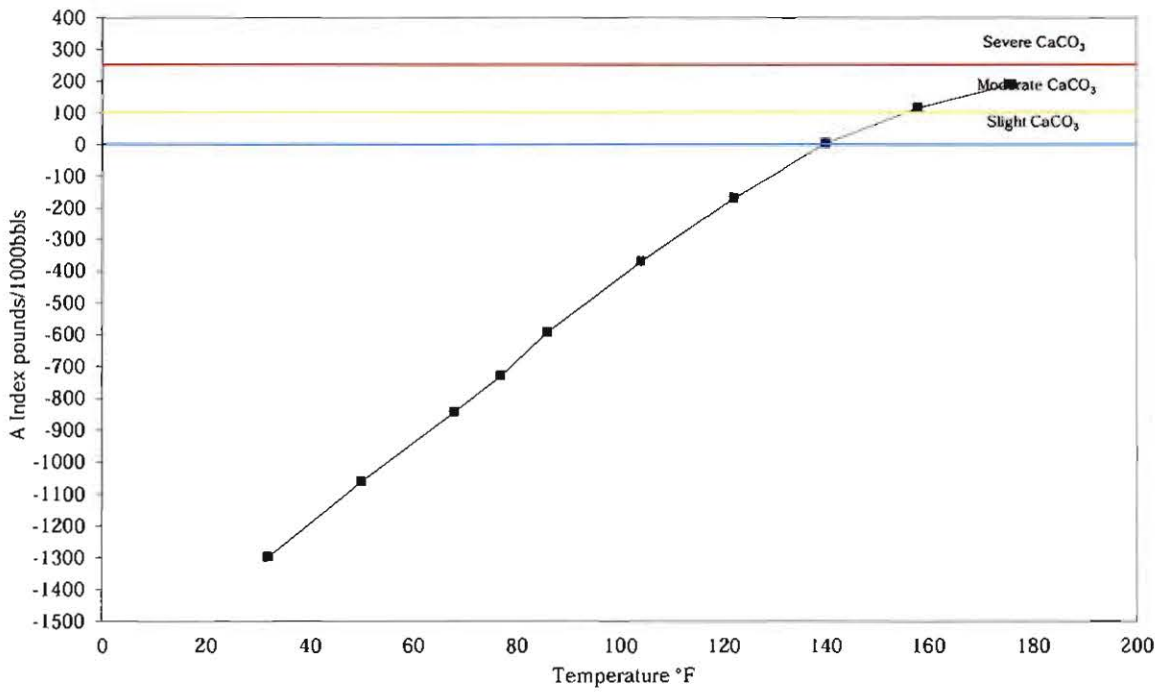
| Compound | mg/L |
|---|---|
| NaCl | 42,593 |
| Na2SO4 | 0 |
| CaSO4 | 0 |
| CaCO3 | 389 |
| MgSO4 | 0 |
| KCl | 134 |
| SrSO4 | 0 |
| BaSO4 | 0 |
| NaHCO3 | 0 |
| MgCO3 | 0 |
| CaCl2 | 1,456 |
| MgCl2 | 356 |

E - Estimated value. Result exceeds the instrument upper quantitation limit, Therefore Schlumberger Gen-9 Value Appears.
H - Analysis performed past recommended holding time.
NA - Not Analyzed

# STIFF - DAVIS REPORT
## Calcium Carbonate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-002 | Date Received: | 3/24/2014 |
| Sample ID: | Warren 17-1CH | Matrix: | Water |

| Temperature | | Stiff-Davis | Aggressivity |
|---|---|---|---|
| C | F | Index | Index |
| 0 | 32 | -1.27 | -1300 |
| 10 | 50 | -1.14 | -1062 |
| 20 | 68 | -1.00 | -843 |
| 25 | 77 | -0.91 | -729 |
| 30 | 86 | -0.80 | -592 |
| 40 | 104 | -0.58 | -370 |
| 50 | 122 | -0.32 | -168 |
| 60 | 140 | 0.01 | 4 |
| 70 | 158 | 0.33 | 115 |
| 80 | 176 | 0.68 | 189 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.33 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.801 µ | Downhole temperature : | 68 °F |

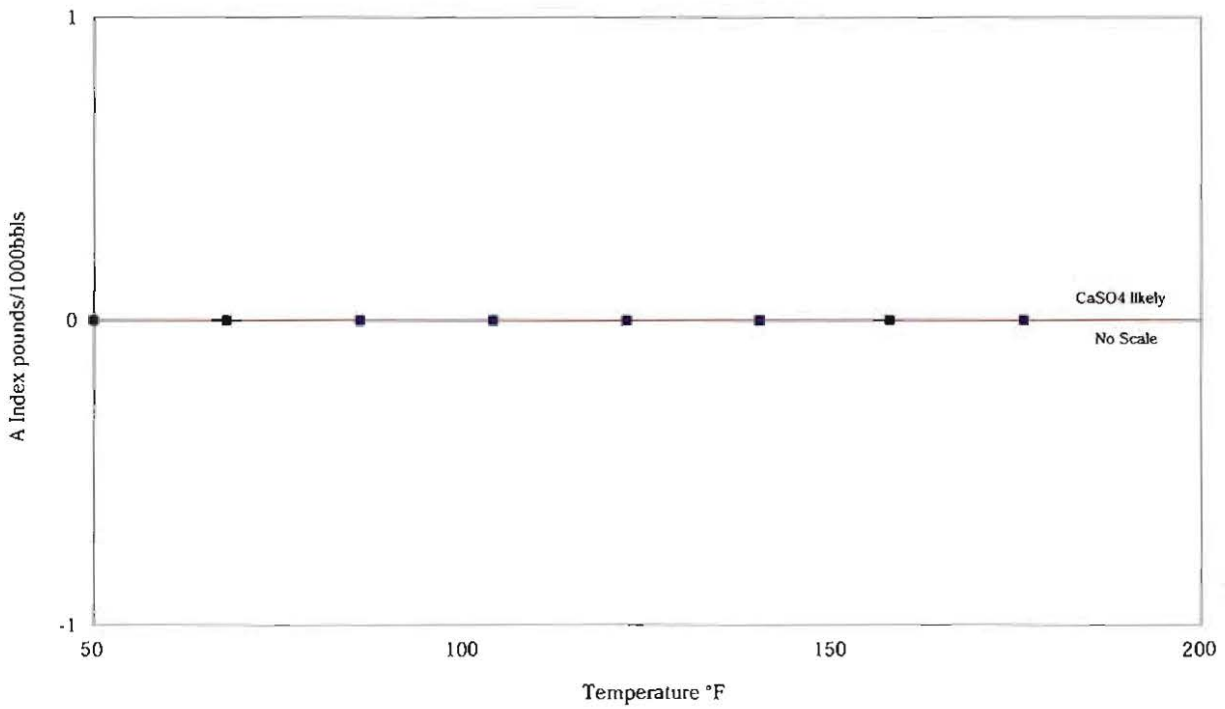
| NOTE: Stiff Davis Index | NOTE: A Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index > 0 - 100 Slight scaling. |
| 0 Saturation point, scale unlikely. | A Index > 100 - 250 Moderate scaling. |
| + Supersaturation, scaling condition. | A Index > 250 + Severe scaling. |

04/10/14

# Skillman Method
## Calcium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-002 | Date Received: | 3/24/2014 |
| Sample ID: | Warren 17-1CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 10 | 50 | 0.00 | - | 62.74 | = | nd | ND |
| 20 | 68 | 0.00 | - | 63.04 | = | nd | ND |
| 30 | 86 | 0.00 | - | 63.26 | = | nd | ND |
| 40 | 104 | 0.00 | - | 63.31 | = | nd | ND |
| 50 | 122 | 0.00 | - | 63.14 | = | nd | ND |
| 60 | 140 | 0.00 | - | 62.61 | = | nd | ND |
| 70 | 158 | 0.00 | - | 61.68 | = | nd | ND |
| 80 | 176 | 0.00 | - | 60.24 | = | nd | ND |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.33 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.801 µ | Downhole temperature : | 68 °F |

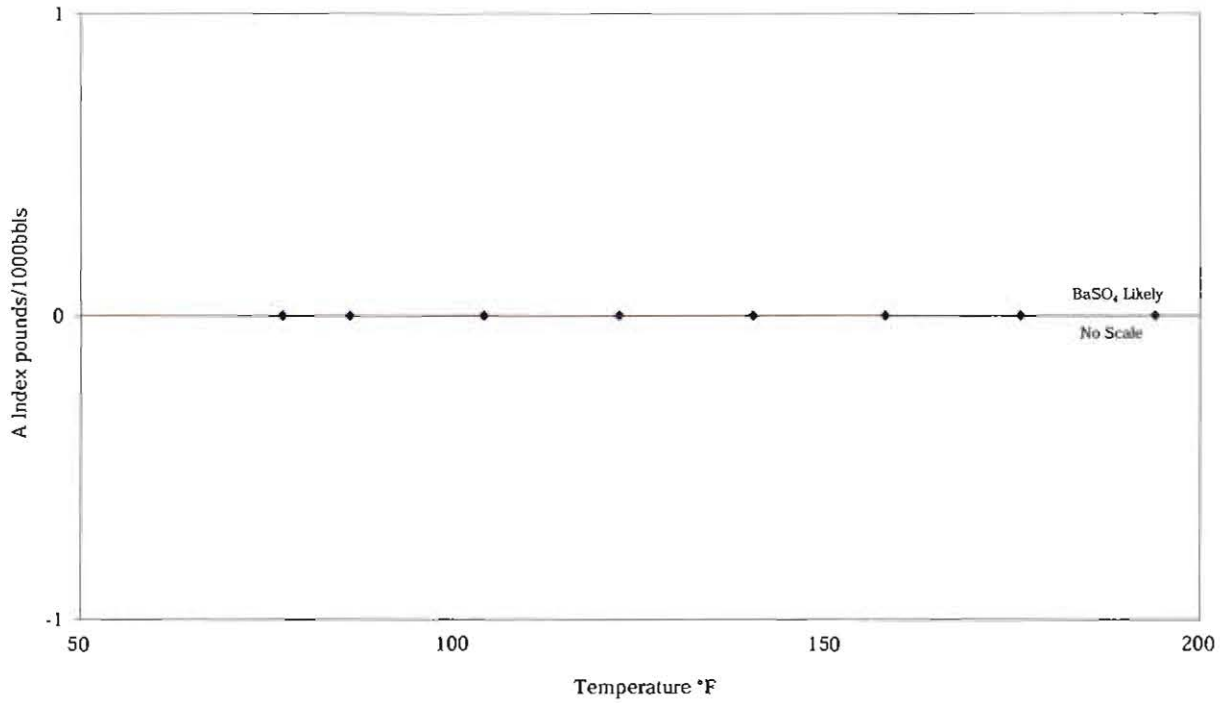
| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation positive. |
| + Supersaturation, scaling condition. | |

04/10/14

# Skillman Method
## Barium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-002 | Date Received: | 3/24/2014 |
| Sample ID: | Warren 17-1CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 25 | 77 | 0.00000 | - | 0.03412 | = | -0.03412 | ND |
| 30 | 86 | 0.00000 | - | 0.03599 | = | -0.03599 | ND |
| 40 | 104 | 0.00000 | - | 0.04022 | = | -0.04022 | ND |
| 50 | 122 | 0.00000 | - | 0.04490 | = | -0.04490 | ND |
| 60 | 140 | 0.00000 | - | 0.05099 | = | -0.05099 | ND |
| 70 | 158 | 0.00000 | - | 0.05655 | = | -0.05655 | ND |
| 80 | 176 | 0.00000 | - | 0.06157 | = | -0.06157 | ND |
| 90 | 194 | 0.00000 | - | 0.06631 | = | -0.06631 | ND |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.33 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.801 µ | Downhole temperature : | 68 °F |

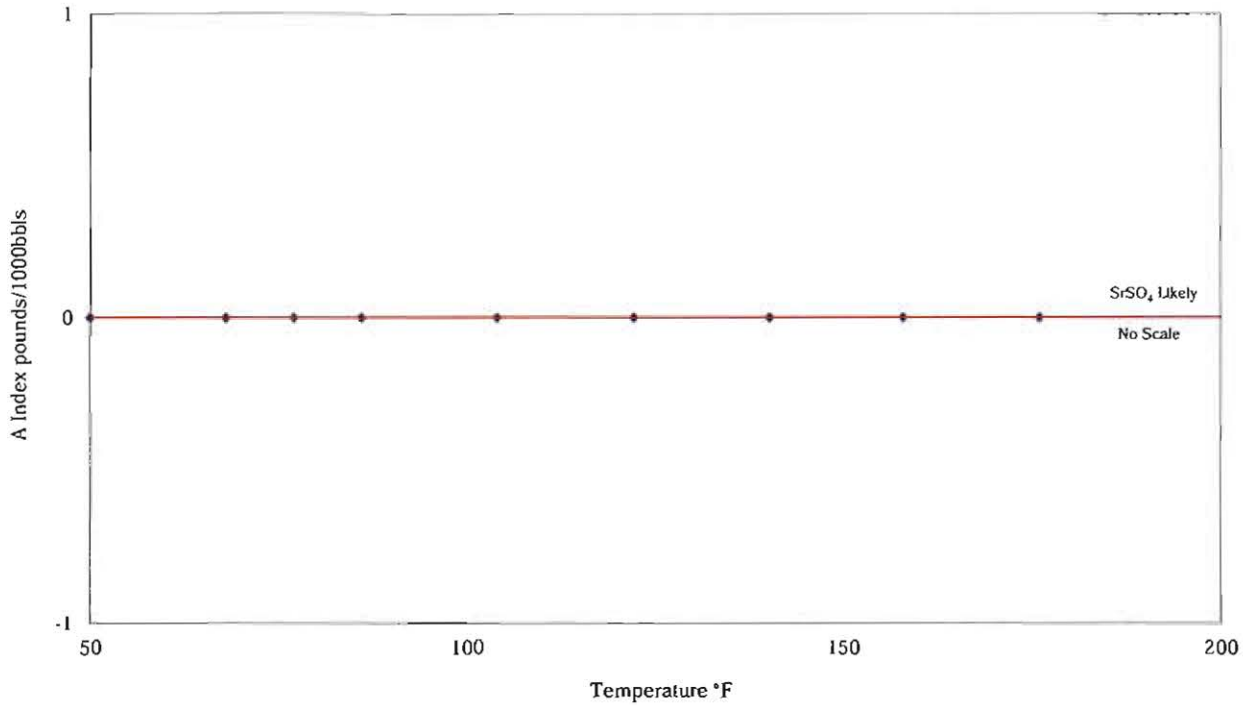
| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation could occur. |
| + Supersaturation, scaling condition. | |

04/10/14

# Skillman Method
## Strontium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-002 | Date Received: | 3/24/2014 |
| Sample ID: | Warren 17-1CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 10 | 50 | 0.00 | - | 6.07 | = | -6.07 | ND |
| 20 | 68 | 0.00 | - | 5.79 | = | -5.79 | ND |
| 25 | 77 | 0.00 | - | 5.64 | = | -5.64 | ND |
| 30 | 86 | 0.00 | - | 5.48 | = | -5.48 | ND |
| 40 | 104 | 0.00 | - | 5.20 | = | -5.20 | ND |
| 50 | 122 | 0.00 | - | 5.01 | = | -5.01 | ND |
| 60 | 140 | 0.00 | - | 4.95 | = | -4.95 | ND |
| 70 | 158 | 0.00 | - | 5.07 | = | -5.07 | ND |
| 80 | 176 | 0.00 | - | 5.44 | = | -5.44 | ND |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.33 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.801 µ | Downhole temperature : | 68 °F |

| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation could occur. |
| + Supersaturation, scaling condition. | |

04/10/14

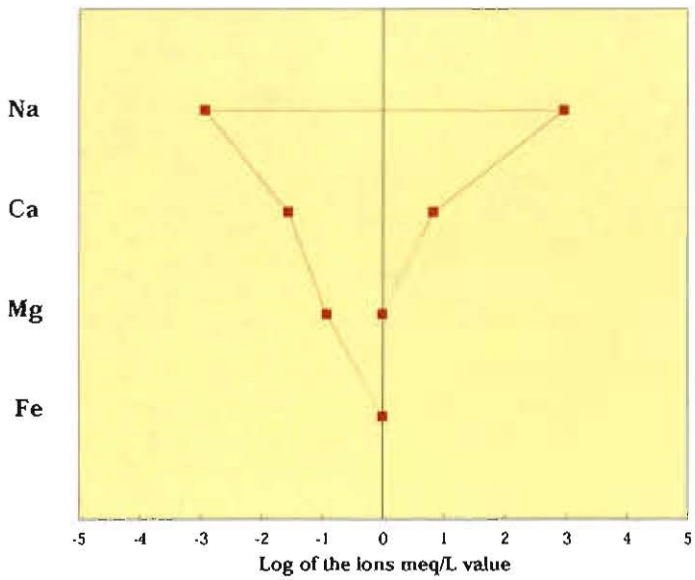
# LABORATORY ANALYTICAL REPORT

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Date Received: | 3/24/2014 |
| Location: | NOT GIVEN | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-003 | Matrix: | Water |
| Sample ID: | Dewey 7-9-1CH | | |

| CATIONS | mg/L | meq/L | ANIONS | mg/L | meq/L |
|---|---|---|---|---|---|
| Calcium | 720 | 35.94 | Bicarbonate | 417 | 6.84 |
| Magnesium | 102 | 8.36 | Carbonate | <1 | <0.03 |
| Potassium | 163 | 4.17 | Hydroxide | <1 | <0.06 |
| Sodium | 19,281 | 838.68 | Chloride | 33,160 | 935.32 |
| Iron, Dissolved | 0.74 | 0.03 | Sulfate | 7 | 0.15 |
| Barium, Dissolved | 65.43 | 0.95 | | | |
| Strontium, Dissolved | 160.97 | 3.67 | | | |
| **SUM +** | **20,493** | **891.80** | **SUM -** | **33,584** | **942.31** |

| Solids | | | Sample Conditions | | |
|---|---|---|---|---|---|
| Total Dissolved Solids, Calc | 53,600 | mg/L | Temperature, °F | 68 °F | |
| Total Solids, NaCl equivalents | 52,747 | mg/L | pH, s.u. | 6.44 s.u. | H |
| Chloride as NaCl | 54,662 | mg/L | Accuracy | 3.44 Sigma | |
| NaCl % of Total Dissolved Solids | 91.4 | % | Cation/Anion Balance | -2.76 % | |
| **Other Properties** | | | | | |
| Calcium Hardness as $CaCO_3$ | 1,798 | mg/L | Ionic Strength | 0.942 µ | |
| Magnesium Hardness as $CaCO_3$ | 418 | mg/L | Specific Gravity, Calc. | 1.036 g/cc | |
| Total Hardness as $CaCO_3$ | 2,217 | mg/L | Resistivity, 68°F | 0.14 ohm meter | E |
| **Microbiological** | | | **Scaling Conditions** | | |
| Sulfate Reducing Bacteria | NA | col/mL | CaCO3: Yes | CaSO4: No | |
| | | | BaSO4: Yes | SrSO4: No | |

**Water Analysis Pattern**




**Probable Mineral Residue, Dry**

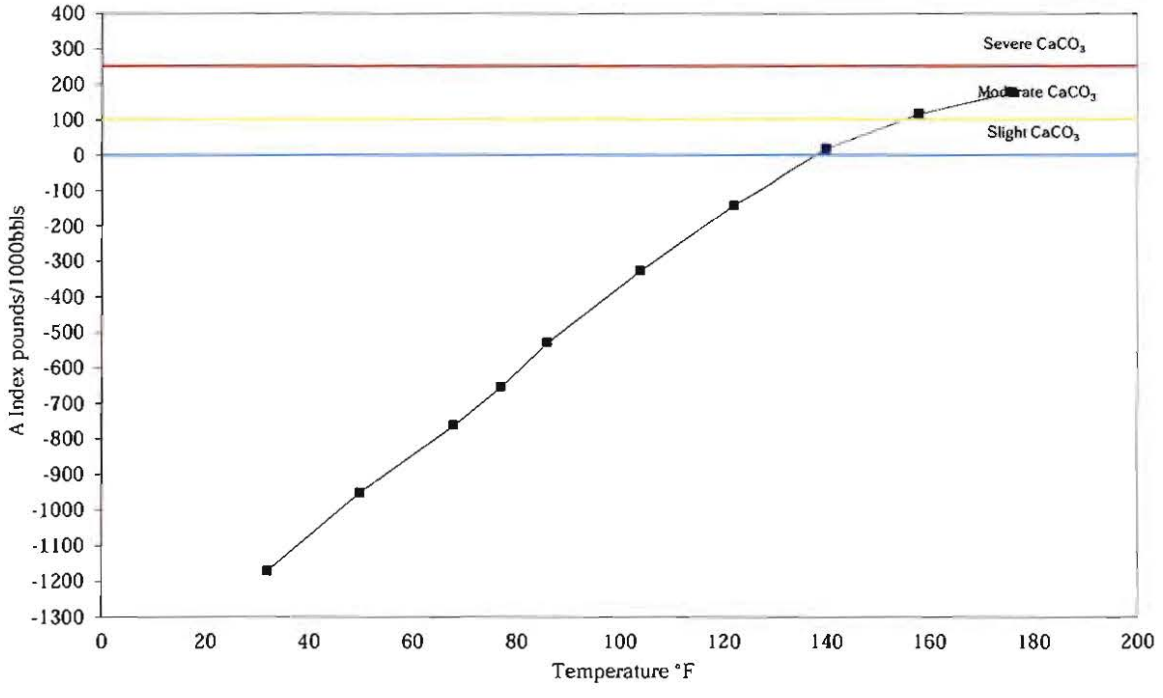
| Compound | mg/L |
|---|---|
| NaCl | 49,014 |
| CaCl2 | 1,615 |
| MgCl2 | 398 |
| CaCO3 | 342 |
| KCl | 311 |
| BaSO4 | 18 |
| Na2SO4 | 0 |
| CaSO4 | 0 |
| MgSO4 | 0 |
| SrSO4 | 0 |
| NaHCO3 | 0 |
| MgCO3 | 0 |

E - Estimated value. Result exceeds the instrument upper quantitation limit, Therefore Schlumberger Gen-9 Value Appears.
H - Analysis performed past recommended holding time.
NA - Not Analyzed

# STIFF - DAVIS REPORT
## Calcium Carbonate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-003 | Date Received: | 3/24/2014 |
| Sample ID: | Dewey 7-9-1CH | Matrix: | Water |

| Temperature | | Stiff-Davis | Aggressivity |
|---|---|---|---|
| C | F | Index | Index |
| 0 | 32 | -1.23 | -1172 |
| 10 | 50 | -1.10 | -951 |
| 20 | 68 | -0.97 | -762 |
| 25 | 77 | -0.88 | -655 |
| 30 | 86 | -0.77 | -529 |
| 40 | 104 | -0.56 | -327 |
| 50 | 122 | -0.29 | -141 |
| 60 | 140 | 0.05 | 18 |
| 70 | 158 | 0.38 | 116 |
| 80 | 176 | 0.73 | 177 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.44 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.942 μ | Downhole temperature : | 68 °F |

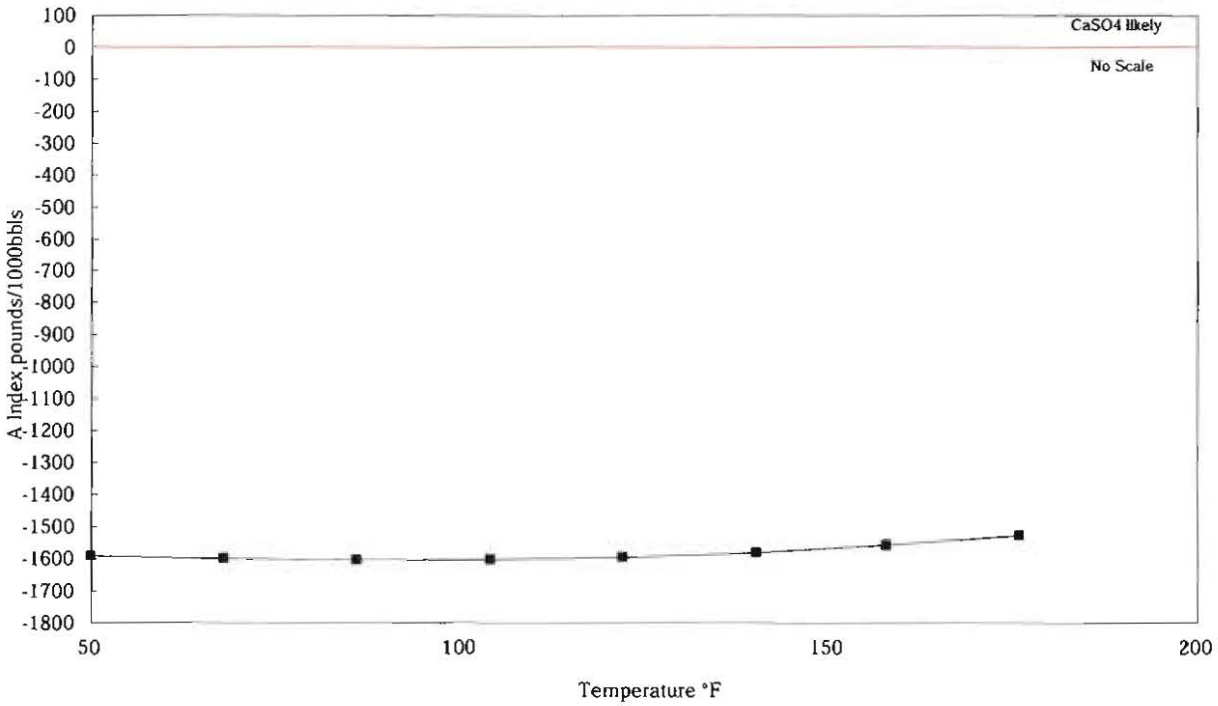
| NOTE: Stiff Davis Index | NOTE: A Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index > 0 - 100 Slight scaling. |
| 0 Saturation point, scale unlikely. | A Index > 100 - 250 Moderate scaling. |
| + Supersaturation, scaling condition. | A Index > 250 + Severe scaling. |

04/10/14

# Skillman Method
## Calcium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-003 | Date Received: | 3/24/2014 |
| Sample ID: | Dewey 7-9-1CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 10 | 50 | 0.15 | - | 66.88 | = | -66.73 | -1590 |
| 20 | 68 | 0.15 | - | 67.24 | = | -67.09 | -1599 |
| 30 | 86 | 0.15 | - | 67.42 | = | -67.27 | -1603 |
| 40 | 104 | 0.15 | - | 67.39 | = | -67.24 | -1603 |
| 50 | 122 | 0.15 | - | 67.09 | = | -66.94 | -1595 |
| 60 | 140 | 0.15 | - | 66.48 | = | -66.33 | -1581 |
| 70 | 158 | 0.15 | - | 65.53 | = | -65.38 | -1558 |
| 80 | 176 | 0.15 | - | 64.20 | = | -64.05 | -1527 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.44 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.942 μ | Downhole temperature : | 68 °F |

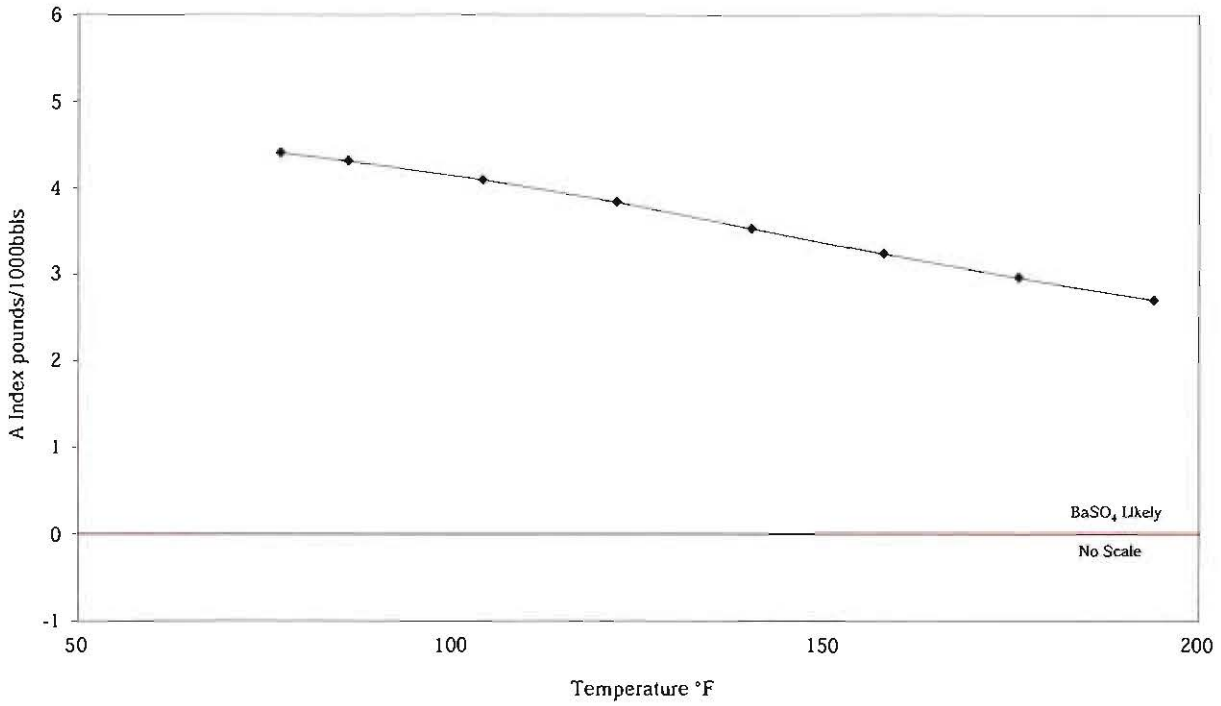
| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation positive. |
| + Supersaturation, scaling condition. | |

04/10/14

# Skillman Method
## Barium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-003 | Date Received: | 3/24/2014 |
| Sample ID: | Dewey 7-9-1CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 25 | 77 | 0.15000 | - | 0.04433 | = | 0.10567 | 4.404 |
| 30 | 86 | 0.15000 | - | 0.04657 | = | 0.10343 | 4.312 |
| 40 | 104 | 0.15000 | - | 0.05193 | = | 0.09807 | 4.093 |
| 50 | 122 | 0.15000 | - | 0.05811 | = | 0.09189 | 3.841 |
| 60 | 140 | 0.15000 | - | 0.06573 | = | 0.08427 | 3.529 |
| 70 | 158 | 0.15000 | - | 0.07296 | = | 0.07704 | 3.234 |
| 80 | 176 | 0.15000 | - | 0.07982 | = | 0.07018 | 2.953 |
| 90 | 194 | 0.15000 | - | 0.08612 | = | 0.06388 | 2.696 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.44 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.942 μ | Downhole temperature : | 68 °F |

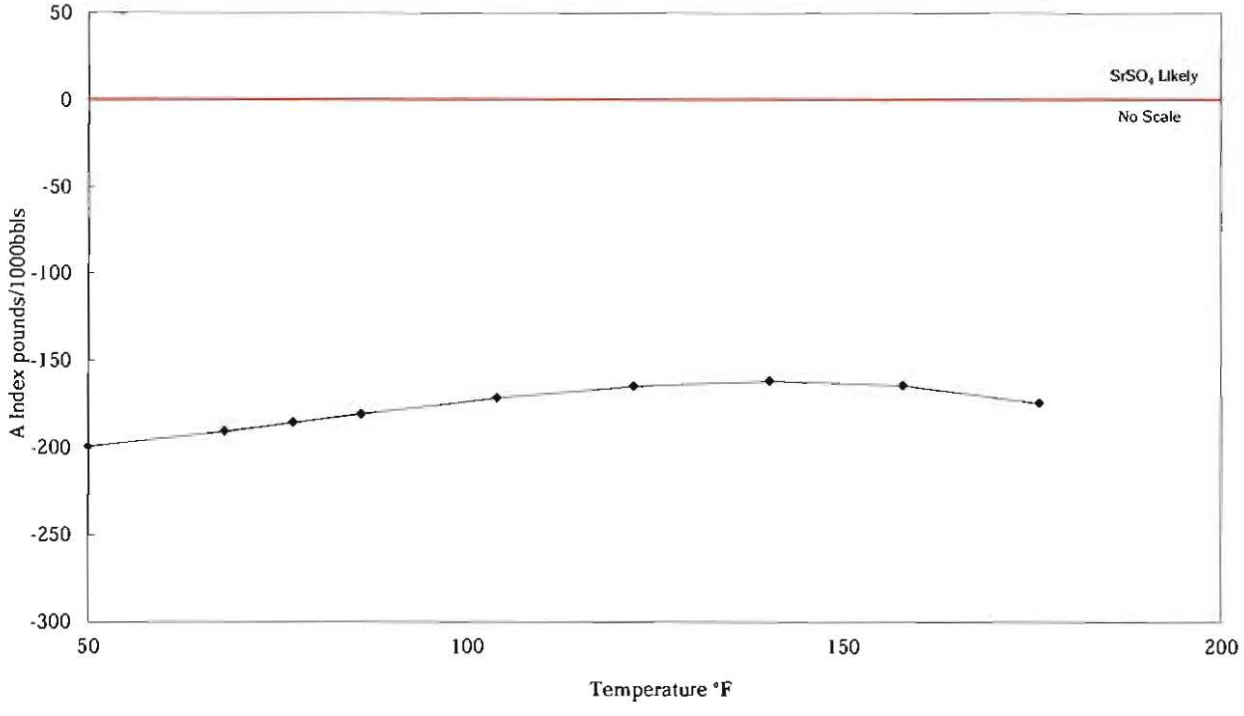
| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation could occur. |
| + Supersaturation, scaling condition. | |

04/10/14

# Skillman Method
## Strontium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-003 | Date Received: | 3/24/2014 |
| Sample ID: | Dewey 7-9-1CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 10 | 50 | 0.15 | - | 6.35 | = | -6.20 | -199.46 |
| 20 | 68 | 0.15 | - | 6.08 | = | -5.93 | -190.77 |
| 25 | 77 | 0.15 | - | 5.93 | = | -5.78 | -185.83 |
| 30 | 86 | 0.15 | - | 5.77 | = | -5.62 | -180.79 |
| 40 | 104 | 0.15 | - | 5.49 | = | -5.34 | -171.54 |
| 50 | 122 | 0.15 | - | 5.27 | = | -5.12 | -164.70 |
| 60 | 140 | 0.15 | - | 5.18 | = | -5.03 | -161.78 |
| 70 | 158 | 0.15 | - | 5.26 | = | -5.11 | -164.37 |
| 80 | 176 | 0.15 | - | 5.58 | = | -5.43 | -174.53 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.44 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.942 μ | Downhole temperature : | 68 °F |

| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation could occur. |
| + Supersaturation, scaling condition. | |

04/10/14

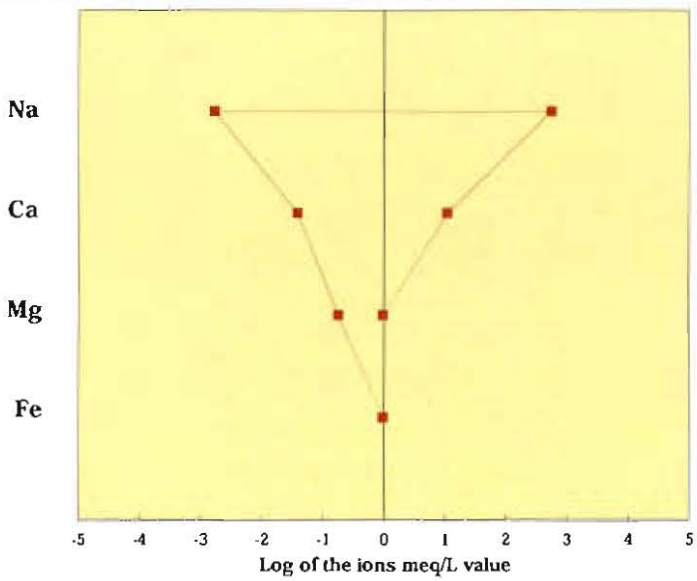
# LABORATORY ANALYTICAL REPORT

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Date Received: | 3/24/2014 |
| Location: | NOT GIVEN | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-004 | Matrix: | Water |
| Sample ID: | Rimrock 33-4-6-2CH | | |

| CATIONS | mg/L | meq/L | ANIONS | mg/L | meq/L |
|---|---|---|---|---|---|
| Calcium | 506 | 25.23 | Bicarbonate | 698 | 11.44 |
| Magnesium | 65 | 5.37 | Carbonate | <1 | <0.03 |
| Potassium | 77 | 1.96 | Hydroxide | <1 | <0.06 |
| Sodium | 13,314 | 579.13 | Chloride | 20,392 | 575.18 |
| Iron, Dissolved | 16.49 | 0.59 | Sulfate | 22 | 0.45 |
| Barium, Dissolved | 35.02 | 0.51 | | | |
| Strontium, Dissolved | 94.29 | 2.15 | | | |
| **SUM +** | **14,107** | **614.94** | **SUM -** | **21,111** | **587.07** |

| Solids | | | Sample Conditions | | |
|---|---|---|---|---|---|
| Total Dissolved Solids, Calc | 34,700 | mg/L | Temperature, °F | 68 °F | |
| Total Solids, NaCl equivalents | 34,190 | mg/L | pH, s.u. | 6.65 s.u. | H |
| Chloride as NaCl | 33,615 | mg/L | Accuracy | -3.02 Sigma | |
| NaCl % of Total Dissolved Solids | 93.6 | % | Cation/Anion Balance | 2.32 % | |
| **Other Properties** | | | | | |
| Calcium Hardness as $CaCO_3$ | 1,263 | mg/L | Ionic Strength | 0.618 µ | |
| Magnesium Hardness as $CaCO_3$ | 269 | mg/L | Specific Gravity, Calc. | 1.023 g/cc | |
| Total Hardness as $CaCO_3$ | 1,531 | mg/L | Resistivity, 68°F | 0.20 ohm meter | E |
| **Microbiological** | | | **Scaling Conditions** | | |
| Sulfate Reducing Bacteria | NA | col/mL | CaCO3: Yes | CaSO4: No | |
| | | | BaSO4: Yes | SrSO4: No | |

**Water Analysis Pattern**




**Probable Mineral Residue, Dry**

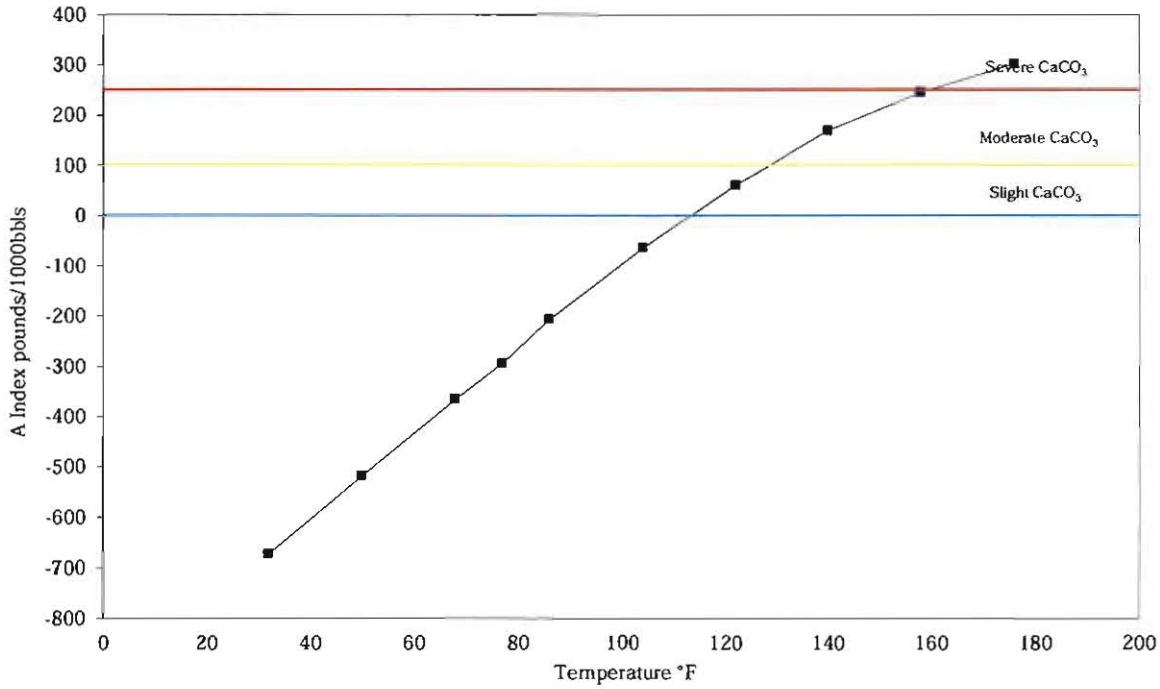
| Compound | mg/L |
|---|---|
| NaCl | 32,495 |
| CaCl2 | 765 |
| CaCO3 | 572 |
| MgCl2 | 256 |
| BaSO4 | 53 |
| Na2SO4 | 0 |
| CaSO4 | 0 |
| MgSO4 | 0 |
| KCl | 0 |
| SrSO4 | 0 |
| NaHCO3 | 0 |
| MgCO3 | 0 |

E - Estimated value. Result exceeds the instrument upper quantitation limit, Therefore Schlumberger Gen-9 Value Appears.
H - Analysis performed past recommended holding time.
NA - Not Analyzed

# STIFF - DAVIS REPORT
## Calcium Carbonate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-004 | Date Received: | 3/24/2014 |
| Sample ID: | Rimrock 33-4-6-2CH | Matrix: | Water |

| Temperature C | Temperature F | Stiff-Davis Index | Aggressivity Index |
|---|---|---|---|
| 0 | 32 | -0.83 | -673 |
| 10 | 50 | -0.70 | -518 |
| 20 | 68 | -0.54 | -366 |
| 25 | 77 | -0.46 | -294 |
| 30 | 86 | -0.35 | -207 |
| 40 | 104 | -0.12 | -65 |
| 50 | 122 | 0.14 | 61 |
| 60 | 140 | 0.45 | 169 |
| 70 | 158 | 0.76 | 245 |
| 80 | 176 | 1.11 | 302 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.65 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.618 µ | Downhole temperature : | 68 °F |

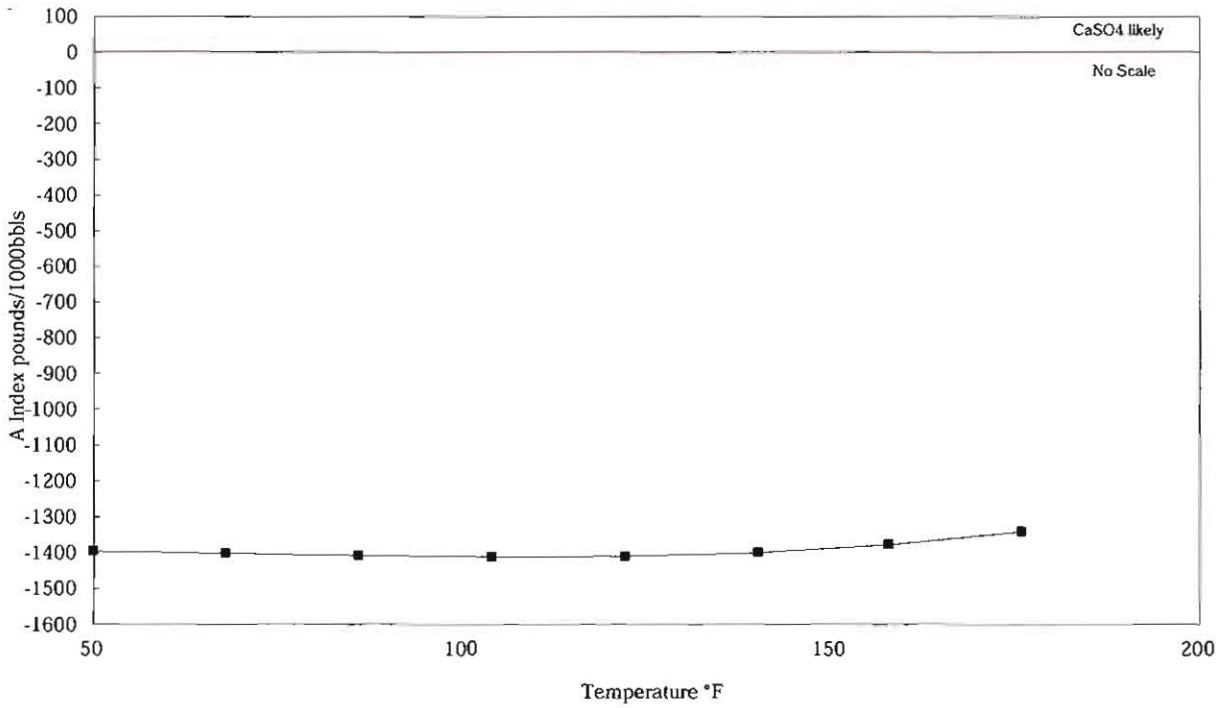
| NOTE: Stiff Davis Index | NOTE: A Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index > 0 - 100 Slight scaling. |
| 0 Saturation point, scale unlikely. | A Index > 100 - 250 Moderate scaling. |
| + Supersaturation, scaling condition. | A Index > 250 + Severe scaling. |

04/10/14

# Skillman Method
## Calcium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-004 | Date Received: | 3/24/2014 |
| Sample ID: | Rimrock 33-4-6-2CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 10 | 50 | 0.45 | - | 59.00 | = | -58.55 | -1395 |
| 20 | 68 | 0.45 | - | 59.26 | = | -58.81 | -1402 |
| 30 | 86 | 0.45 | - | 59.53 | = | -59.08 | -1408 |
| 40 | 104 | 0.45 | - | 59.69 | = | -59.24 | -1412 |
| 50 | 122 | 0.45 | - | 59.63 | = | -59.18 | -1410 |
| 60 | 140 | 0.45 | - | 59.19 | = | -58.74 | -1400 |
| 70 | 158 | 0.45 | - | 58.25 | = | -57.80 | -1378 |
| 80 | 176 | 0.45 | - | 56.76 | = | -56.31 | -1342 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.65 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.618 µ | Downhole temperature : | 68 °F |

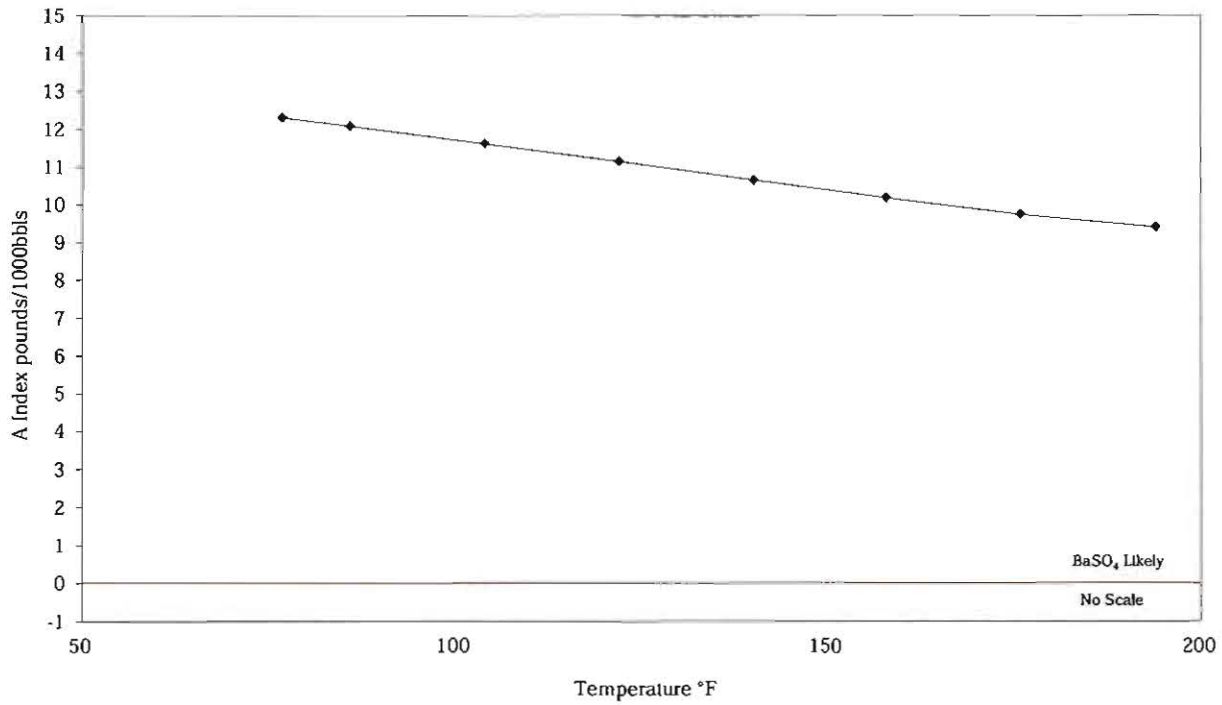
| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation positive. |
| + Supersaturation, scaling condition. | |

04/10/14

# Skillman Method
## Barium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-004 | Date Received: | 3/24/2014 |
| Sample ID: | Rimrock 33-4-6-2CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 25 | 77 | 0.45000 | - | 0.15093 | = | 0.29907 | 12.293 |
| 30 | 86 | 0.45000 | - | 0.15640 | = | 0.29360 | 12.069 |
| 40 | 104 | 0.45000 | - | 0.16763 | = | 0.28237 | 11.610 |
| 50 | 122 | 0.45000 | - | 0.17895 | = | 0.27105 | 11.148 |
| 60 | 140 | 0.45000 | - | 0.19112 | = | 0.25888 | 10.651 |
| 70 | 158 | 0.45000 | - | 0.20255 | = | 0.24745 | 10.184 |
| 80 | 176 | 0.45000 | - | 0.21334 | = | 0.23666 | 9.743 |
| 90 | 194 | 0.45000 | - | 0.22169 | = | 0.22831 | 9.401 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.65 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.618 μ | Downhole temperature : | 68 °F |

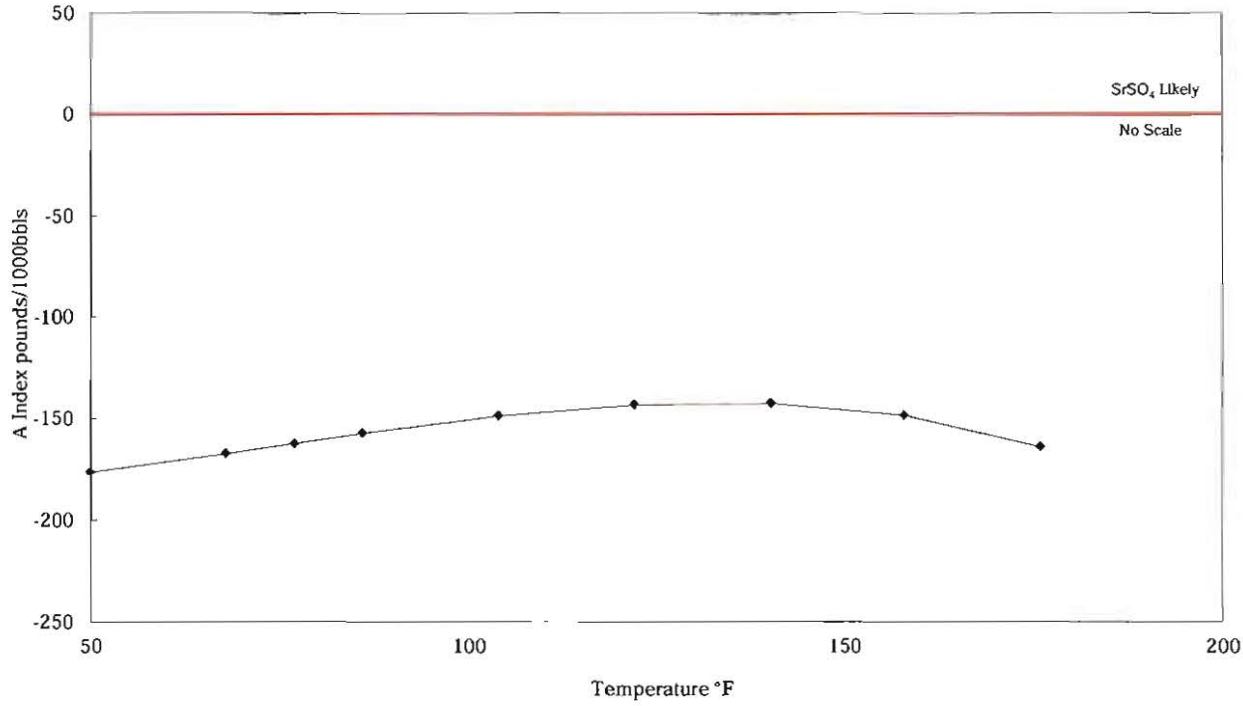
| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation could occur. |
| + Supersaturation, scaling condition. | |

04/10/14

# Skillman Method
## Strontium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-004 | Date Received: | 3/24/2014 |
| Sample ID: | Rimrock 33-4-6-2CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 10 | 50 | 0.45 | - | 5.94 | = | -5.49 | -176.50 |
| 20 | 68 | 0.45 | - | 5.66 | = | -5.21 | -167.37 |
| 25 | 77 | 0.45 | - | 5.50 | = | -5.05 | -162.46 |
| 30 | 86 | 0.45 | - | 5.35 | = | -4.90 | -157.43 |
| 40 | 104 | 0.45 | - | 5.08 | = | -4.63 | -148.82 |
| 50 | 122 | 0.45 | - | 4.91 | = | -4.46 | -143.32 |
| 60 | 140 | 0.45 | - | 4.89 | = | -4.44 | -142.60 |
| 70 | 158 | 0.45 | - | 5.07 | = | -4.62 | -148.56 |
| 80 | 176 | 0.45 | - | 5.55 | = | -5.10 | -164.07 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.65 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.618 μ | Downhole temperature : | 68 °F |

| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation could occur. |
| + Supersaturation, scaling condition. | |

04/10/14

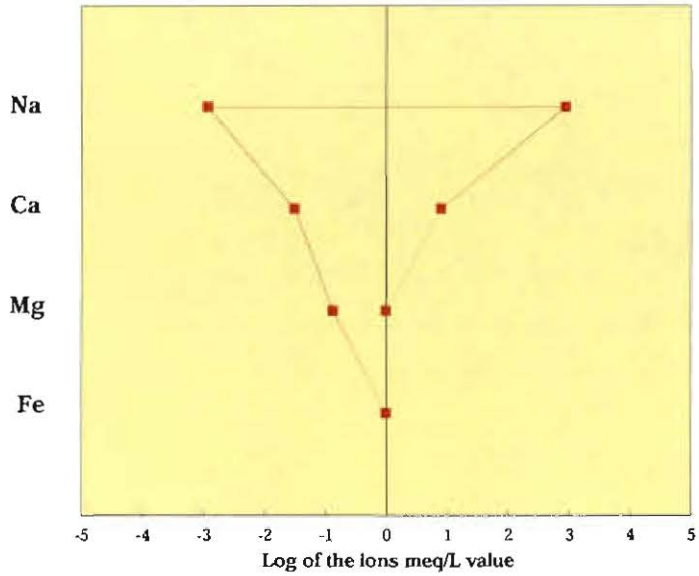
# LABORATORY ANALYTICAL REPORT

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Date Received: | 3/24/2014 |
| Location: | NOT GIVEN | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-005 | Matrix: | Water |
| Sample ID: | Gaviota 35-12-1CH | | |

| CATIONS | mg/L | meq/L | ANIONS | mg/L | meq/L |
|---|---|---|---|---|---|
| Calcium | 625 | 31.17 | Bicarbonate | 496 | 8.13 |
| Magnesium | 89 | 7.32 | Carbonate | <1 | <0.03 |
| Potassium | 123 | 3.14 | Hydroxide | <1 | <0.06 |
| Sodium | 18,970 | 825.15 | Chloride | 32,089 | 905.13 |
| Iron, Dissolved | 11.83 | 0.42 | Sulfate | 12 | 0.25 |
| Barium, Dissolved | 68.40 | 1.00 | | | |
| Strontium, Dissolved | 148.37 | 3.39 | | | |
| **SUM +** | **20,035** | **871.59** | **SUM -** | **32,597** | **913.51** |

| Solids | | | Sample Conditions | | |
|---|---|---|---|---|---|
| Total Dissolved Solids, Calc | 52,200 | mg/L | Temperature, °F | 68 | °F |
| Total Solids, NaCl equivalents | 51,443 | mg/L | pH, s.u. | 6.53 | s.u. H |
| Chloride as NaCl | 52,898 | mg/L | Accuracy | 2.94 | Sigma |
| NaCl % of Total Dissolved Solids | 92.4 | % | Cation/Anion Balance | -2.35 | % |
| **Other Properties** | | | | | |
| Calcium Hardness as $CaCO_3$ | 1,560 | mg/L | Ionic Strength | 0.914 | µ |
| Magnesium Hardness as $CaCO_3$ | 366 | mg/L | Specific Gravity, Calc. | 1.035 | g/cc |
| Total Hardness as $CaCO_3$ | 1,926 | mg/L | Resistivity, 68°F | 0.14 | ohm meter E |
| **Microbiological** | | | **Scaling Conditions** | | |
| Sulfate Reducing Bacteria | NA | col/mL | CaCO3: Yes | CaSO4: No | |
| | | | BaSO4: Yes | SrSO4: No | |

**Water Analysis Pattern**




**Probable Mineral Residue, Dry**

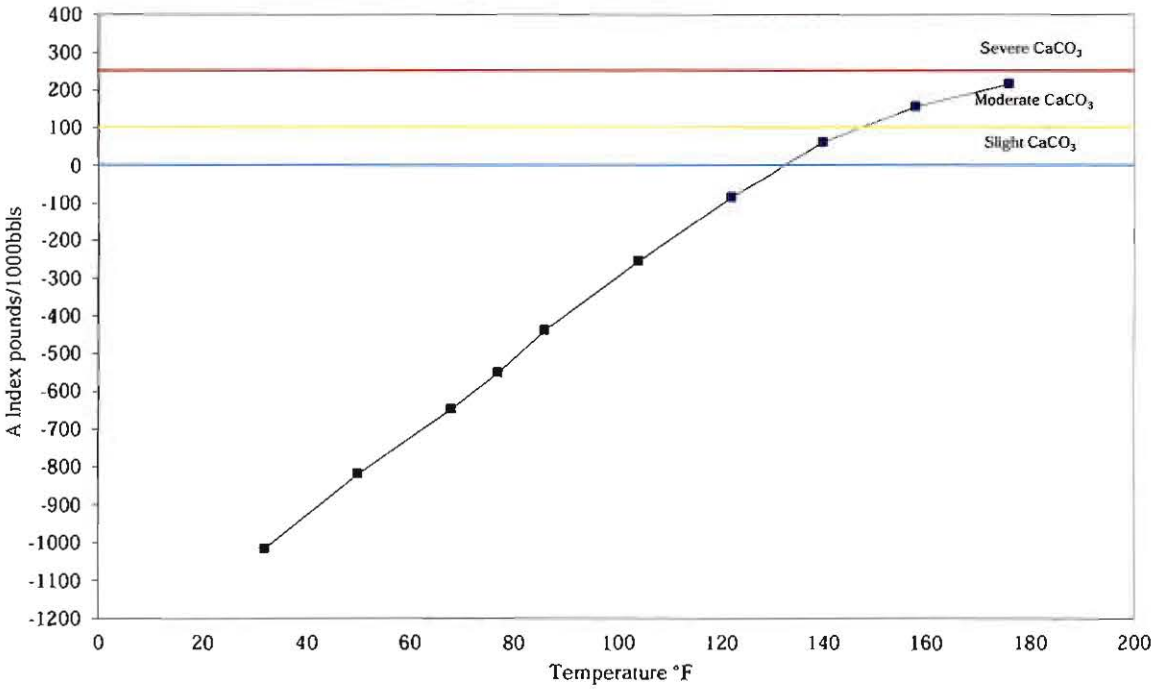
| Compound | mg/L |
|---|---|
| NaCl | 48,224 |
| CaCl2 | 1,278 |
| CaCO3 | 407 |
| MgCl2 | 348 |
| KCl | 234 |
| BaSO4 | 29 |
| Na2SO4 | 0 |
| CaSO4 | 0 |
| MgSO4 | 0 |
| SrSO4 | 0 |
| NaHCO3 | 0 |
| MgCO3 | 0 |

E - Estimated value. Result exceeds the instrument upper quantitation limit, Therefore Schlumberger Gen-9 Value Appears.
H - Analysis performed past recommended holding time.
NA - Not Analyzed

# STIFF - DAVIS REPORT
## Calcium Carbonate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-005 | Date Received: | 3/24/2014 |
| Sample ID: | Gaviota 35-12-1CH | Matrix: | Water |

| Temperature | | Stiff-Davis | Aggressivity |
|---|---|---|---|
| C | F | Index | Index |
| 0 | 32 | -1.12 | -1017 |
| 10 | 50 | -0.99 | -819 |
| 20 | 68 | -0.86 | -647 |
| 25 | 77 | -0.77 | -551 |
| 30 | 86 | -0.66 | -438 |
| 40 | 104 | -0.45 | -255 |
| 50 | 122 | -0.18 | -85 |
| 60 | 140 | 0.15 | 61 |
| 70 | 158 | 0.48 | 155 |
| 80 | 176 | 0.83 | 216 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.53 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.914 μ | Downhole temperature : | 68 °F |

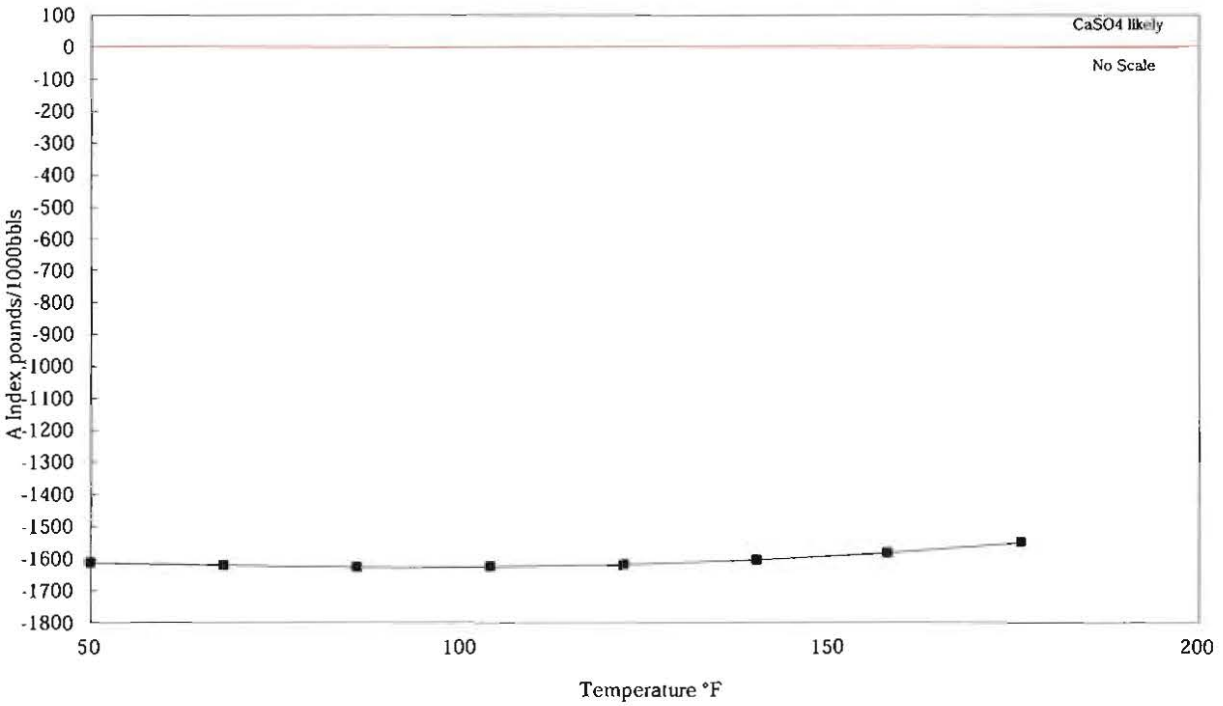
| NOTE: Stiff Davis Index | NOTE: A Index: Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index > 0 - 100 Slight scaling. |
| 0 Saturation point, scale unlikely. | A Index > 100 - 250 Moderate scaling. |
| + Supersaturation, scaling condition. | A Index > 250 + Severe scaling. |

04/10/14

# Skillman Method
## Calcium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-005 | Date Received: | 3/24/2014 |
| Sample ID: | Gaviota 35-12-1CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 10 | 50 | 0.25 | - | 67.95 | = | -67.70 | -1614 |
| 20 | 68 | 0.25 | - | 68.30 | = | -68.05 | -1622 |
| 30 | 86 | 0.25 | - | 68.48 | = | -68.23 | -1626 |
| 40 | 104 | 0.25 | - | 68.47 | = | -68.22 | -1626 |
| 50 | 122 | 0.25 | - | 68.20 | = | -67.95 | -1619 |
| 60 | 140 | 0.25 | - | 67.61 | = | -67.36 | -1605 |
| 70 | 158 | 0.25 | - | 66.66 | = | -66.41 | -1583 |
| 80 | 176 | 0.25 | - | 65.29 | = | -65.04 | -1550 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.53 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.914 µ | Downhole temperature : | 68 °F |

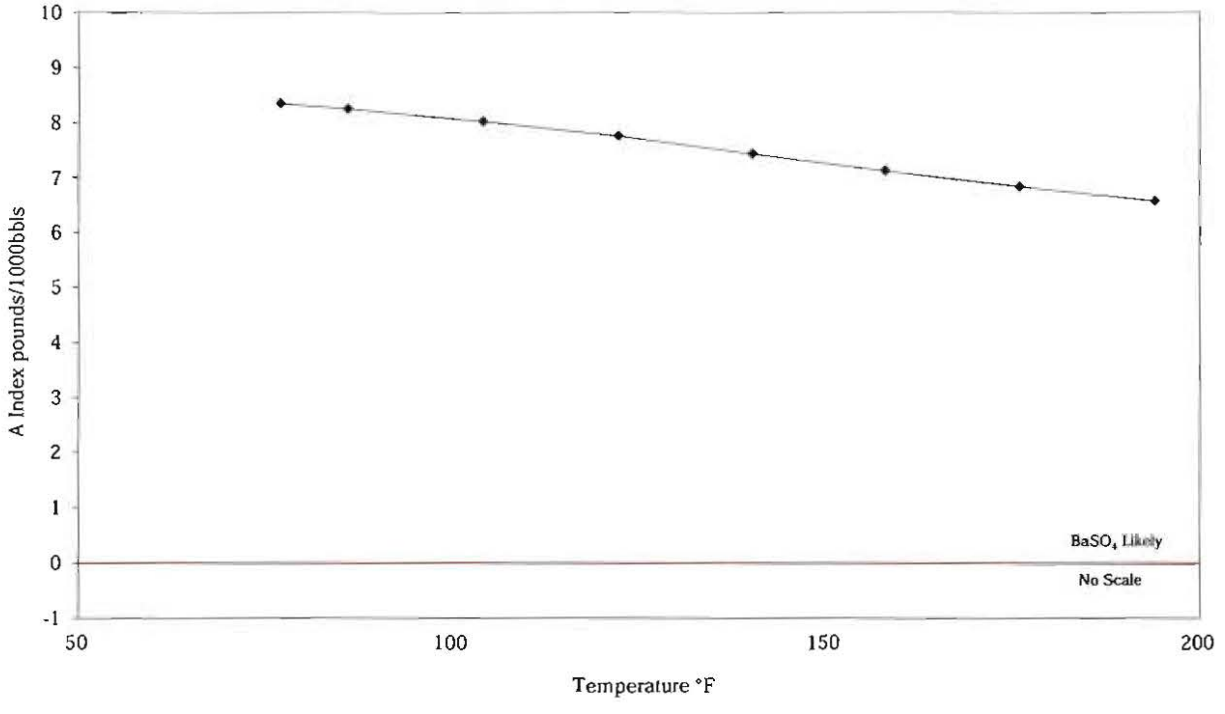
| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation positive. |
| + Supersaturation, scaling condition. | |

04/10/14

# Skillman Method
## Barium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-005 | Date Received: | 3/24/2014 |
| Sample ID: | Gaviota 35-12-1CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 25 | 77 | 0.25000 | - | 0.04676 | = | 0.20324 | 8.345 |
| 30 | 86 | 0.25000 | - | 0.04914 | = | 0.20086 | 8.248 |
| 40 | 104 | 0.25000 | - | 0.05475 | = | 0.19525 | 8.019 |
| 50 | 122 | 0.25000 | - | 0.06116 | = | 0.18884 | 7.757 |
| 60 | 140 | 0.25000 | - | 0.06912 | = | 0.18088 | 7.431 |
| 70 | 158 | 0.25000 | - | 0.07661 | = | 0.17339 | 7.126 |
| 80 | 176 | 0.25000 | - | 0.08363 | = | 0.16637 | 6.839 |
| 90 | 194 | 0.25000 | - | 0.09010 | = | 0.15990 | 6.574 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.53 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.914 μ | Downhole temperature : | 68 °F |

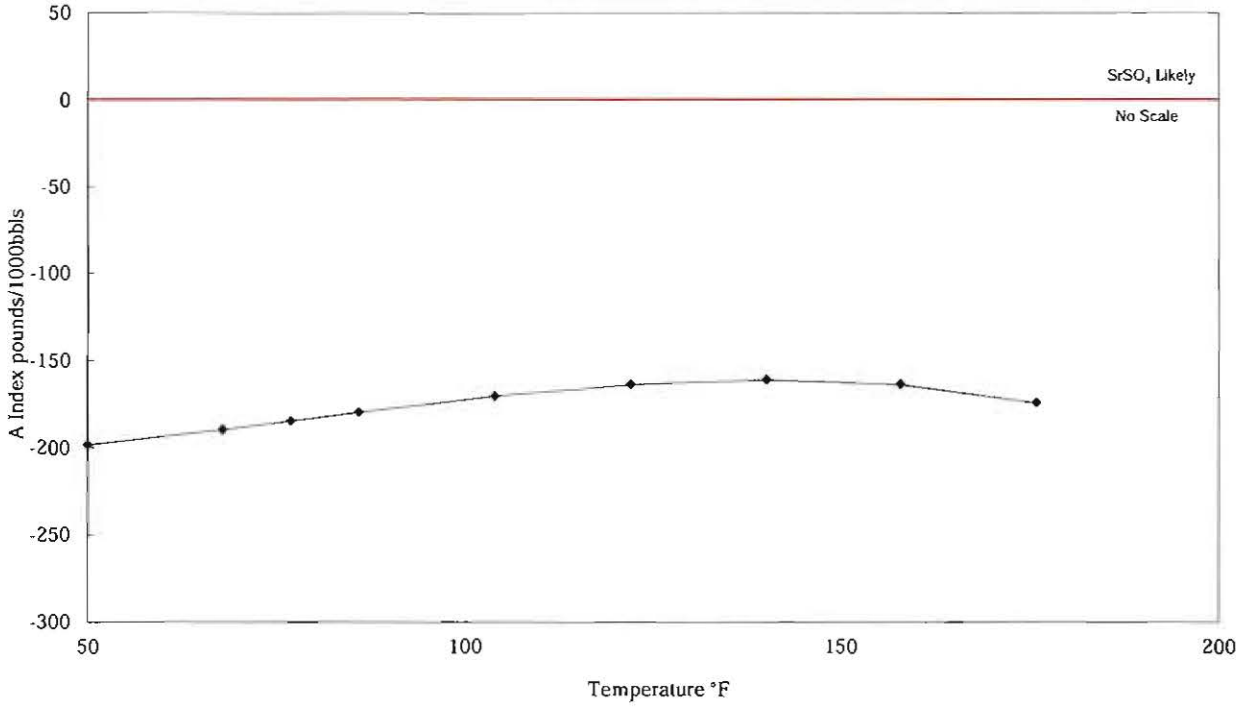
| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation could occur. |
| + Supersaturation, scaling condition. | |

04/10/14

# Skillman Method
## Strontium Sulfate Scale Precipitation Calculations

| | | | |
|---|---|---|---|
| Company: | Cirque Resources LP | Report Date: | 4/10/2014 |
| Project: | Not Indicated | Collection Date: | 3/21/2014 |
| Laboratory ID: | G14030467-005 | Date Received: | 3/24/2014 |
| Sample ID: | Gaviota 35-12-1CH | Matrix: | Water |

| Temperature | | SOLUBILITY | | | | S | A |
|---|---|---|---|---|---|---|---|
| C | F | Actual | | Calculated | | Index | Index |
| 10 | 50 | 0.25 | - | 6.43 | = | -6.18 | -198.62 |
| 20 | 68 | 0.25 | - | 6.15 | = | -5.90 | -189.81 |
| 25 | 77 | 0.25 | - | 6.00 | = | -5.75 | -184.85 |
| 30 | 86 | 0.25 | - | 5.84 | = | -5.59 | -179.78 |
| 40 | 104 | 0.25 | - | 5.55 | = | -5.30 | -170.55 |
| 50 | 122 | 0.25 | - | 5.34 | = | -5.09 | -163.80 |
| 60 | 140 | 0.25 | - | 5.26 | = | -5.01 | -161.04 |
| 70 | 158 | 0.25 | - | 5.35 | = | -5.10 | -163.87 |
| 80 | 176 | 0.25 | - | 5.67 | = | -5.42 | -174.38 |




| Scale calculation parameters | | Temperatures | |
|---|---|---|---|
| pH: | 6.53 s.u. | Surface temperature : | 68 °F |
| Ionic Strength: | 0.914 µ | Downhole temperature : | 68 °F |

| NOTE: 'S' Index | NOTE: 'A' Index; Assumes 100% precipitation lbs/1000bbls |
|---|---|
| - Undersaturation, scale negative. | A Index < = 0 Scale formation negative. |
| 0 Saturation point, scale unlikely. | A Index > 0 Scale formation could occur. |
| + Supersaturation, scaling condition. | |

04/10/14

# QA/QC Summary Report

Prepared by Gillette, WY Branch

**Client:** Cirque Resources LP
**Project:** Not Indicated

**Report Date:** 04/10/14
**Work Order:** G14030467

| Analyte | Result | Units | RL | %REC | Low Limit | High Limit | RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|
| **Method:** A2320 B | | | | | | | | Analytical Run: MAN-TECH_140325A | |
| **Lab ID:** ICV | Initial Calibration Verification Standard | | | | | | | 03/25/14 12:04 | |
| pH | 7.97 | s.u. | 0.010 | 100 | 98 | 102 | | | |
| **Method:** A2320 B | | | | | | | | Batch: R210863 | |
| **Lab ID:** MBLK | Method Blank | | | | Run: MAN-TECH_140325A | | | 03/25/14 15:22 | |
| Alkalinity, Total as CaCO3 | ND | mg/L | 5.0 | | | | | | |
| **Lab ID:** LCS-W | Laboratory Control Sample | | | | Run: MAN-TECH_140325A | | | 03/25/14 15:31 | |
| Alkalinity, Total as CaCO3 | 1040 | mg/L | 5.0 | 94 | 90 | 110 | | | |
| **Lab ID:** G14030467-001ADUP | Sample Duplicate | | | | Run: MAN-TECH_140325A | | | 03/25/14 15:45 | |
| Alkalinity, Total as CaCO3 | 419 | mg/L | 5.0 | | | | 0.1 | 10 | |
| **Lab ID:** G14030467-002AMS | Sample Matrix Spike | | | | Run: MAN-TECH_140325A | | | 03/25/14 16:02 | |
| Alkalinity, Total as CaCO3 | 1460 | mg/L | 5.0 | 95 | 80 | 120 | | | |
| **Method:** A2320 B | | | | | | | | Analytical Run: MAN-TECH_140403A | |
| **Lab ID:** ICV | Initial Calibration Verification Standard | | | | | | | 04/03/14 13:00 | |
| pH | 7.98 | s.u. | 0.010 | 100 | 98 | 102 | | | |
| **Method:** A2320 B | | | | | | | | Batch: R211055 | |
| **Lab ID:** MBLK | Method Blank | | | | Run: MAN-TECH_140403A | | | 04/03/14 13:10 | |
| Alkalinity, Total as CaCO3 | ND | mg/L | 3 | | | | | | |
| **Lab ID:** LCS-W | Laboratory Control Sample | | | | Run: MAN-TECH_140403A | | | 04/03/14 13:18 | |
| Alkalinity, Total as CaCO3 | 1080 | mg/L | 5.0 | 97 | 90 | 110 | | | |
| **Lab ID:** G14030437-001ADUP | Sample Duplicate | | | | Run: MAN-TECH_140403A | | | 04/03/14 13:32 | |
| Alkalinity, Total as CaCO3 | 102 | mg/L | 5.0 | | | | 0.3 | 10 | |
| **Lab ID:** G14030437-002AMS | Sample Matrix Spike | | | | Run: MAN-TECH_140403A | | | 04/03/14 13:49 | |
| Alkalinity, Total as CaCO3 | 1360 | mg/L | 5.0 | 96 | 80 | 120 | | | |

**Qualifiers:**

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

# QA/QC Summary Report

Prepared by Gillette, WY Branch

**Client:** Cirque Resources LP
**Project:** Not Indicated

**Report Date:** 04/10/14
**Work Order:** G14030467

| Analyte | Result | Units | RL | %REC | Low Limit | High Limit | RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|
| **Method:** A2510 B | | | | | | | | | Batch: R210807 |
| **Lab ID:** SC 100 | Initial Calibration Verification Standard | | | | Run: PHSC_101-G_140324A | | | | 03/24/14 13:27 |
| Conductivity @ 25 C | 104 | umhos/cm | 10 | 104 | 95 | 105 | | | |
| **Lab ID:** SC 5000 | Initial Calibration Verification Standard | | | | Run: PHSC_101-G_140324A | | | | 03/24/14 13:30 |
| Conductivity @ 25 C | 4980 | umhos/cm | 10 | 100 | 95 | 105 | | | |
| **Lab ID:** SC 20000 | Initial Calibration Verification Standard | | | | Run: PHSC_101-G_140324A | | | | 03/24/14 13:33 |
| Conductivity @ 25 C | 19700 | umhos/cm | 10 | 99 | 95 | 105 | | | |
| **Lab ID:** SC 50000 | Initial Calibration Verification Standard | | | | Run: PHSC_101-G_140324A | | | | 03/24/14 13:36 |
| Conductivity @ 25 C | 48300 | umhos/cm | 10 | 97 | 95 | 105 | | | |
| **Lab ID:** MBLK - SC | Method Blank | | | | Run: PHSC_101-G_140324A | | | | 03/24/14 17:03 |
| Conductivity @ 25 C | ND | umhos/cm | 10 | | | | | | |
| **Lab ID:** G14030467-001ADUP | Sample Duplicate | | | | Run: PHSC_101-G_140324A | | | | 03/24/14 17:10 |
| Conductivity @ 25 C | 62800 | umhos/cm | 10 | | | | 0.7 | 5 | |

**Qualifiers:**

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

# QA/QC Summary Report

Prepared by Gillette, WY Branch

**Client:** Cirque Resources LP
**Project:** Not Indicated

**Report Date:** 04/10/14
**Work Order:** G14030467

| Analyte | Result | Units | RL | %REC | Low Limit | High Limit | RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|
| **Method:** A2540 C | | | | | | | | Batch: TDS140325A | |
| **Lab ID:** MB-1_140325A | Method Blank | | | | Run: BAL-MET-AE_140325A | | | 03/25/14 08:42 | |
| Solids, Total Dissolved TDS @ 180 C | ND | mg/L | 4 | | | | | | |
| **Lab ID:** LCS-2_140325A | Laboratory Control Sample | | | | Run: BAL-MET-AE_140325A | | | 03/25/14 08:42 | |
| Solids, Total Dissolved TDS @ 180 C | 1120 | mg/L | 11 | 100 | 90 | 110 | | | |
| **Lab ID:** G14030448-001A MS | Sample Matrix Spike | | | | Run: BAL-MET-AE_140325A | | | 03/25/14 08:43 | |
| Solids, Total Dissolved TDS @ 180 C | 2360 | mg/L | 19 | 101 | 90 | 110 | | | |
| **Lab ID:** G14030452-002A DUP | Sample Duplicate | | | | Run: BAL-MET-AE_140325A | | | 03/25/14 08:46 | |
| Solids, Total Dissolved TDS @ 180 C | 2770 | mg/L | 63 | | | | 0.9 | 5 | |

**Qualifiers:**

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

# QA/QC Summary Report

Prepared by Gillette, WY Branch

**Client:** Cirque Resources LP
**Project:** Not Indicated

**Report Date:** 04/10/14
**Work Order:** G14030467

| Analyte | Result | Units | RL | %REC | Low Limit | High Limit | RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|
| **Method:** A4500-H B | | | | | | | | Analytical Run: PHSC_101-G_140324A | |
| **Lab ID:** pH 8 | Initial Calibration Verification Standard | | | | | | | | 03/24/14 13:24 |
| pH | 7.95 | s.u. | 0.010 | 99 | 98 | 102 | | | |
| **Method:** A4500-H B | | | | | | | | | Batch: R210807 |
| **Lab ID:** G14030467-001ADUP | Sample Duplicate | | | | Run: PHSC_101-G_140324A | | | | 03/24/14 17:10 |
| pH | 6.56 | s.u. | 0.010 | | | | 0.0 | 1.5 | |

**Qualifiers:**

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

# QA/QC Summary Report

Prepared by Gillette, WY Branch

**Client:** Cirque Resources LP
**Project:** Not Indicated

**Report Date:** 04/10/14
**Work Order:** G14030467

| Analyte | | Result | Units | RL | %REC | Low Limit | High Limit | RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| **Method:** | **E300.0** | | | | | | | | Analytical Run: DIONEX-IC1_140325A | |
| **Lab ID:** | ICV/LCS-W | Initial Calibration Verification Standard | | | | | | | 03/25/14 12:20 | |
| Chloride | | 39.4 | mg/L | 1.0 | 98 | 90 | 110 | | | |
| **Method:** | **E300.0** | | | | | | | | Batch: R210864 | |
| **Lab ID:** | ICB | Method Blank | | | | Run: DIONEX-IC1_140325A | | | 03/25/14 12:35 | |
| Chloride | | ND | mg/L | 0.02 | | | | | | |
| **Lab ID:** | LFB | Laboratory Fortified Blank | | | | Run: DIONEX-IC1_140325A | | | 03/25/14 12:50 | |
| Chloride | | 39.7 | mg/L | 1.0 | 101 | 90 | 110 | | | |
| **Lab ID:** | G14030448-001AMS | Sample Matrix Spike | | | | Run: DIONEX-IC1_140325A | | | 03/25/14 16:52 | |
| Chloride | | 203 | mg/L | 1.0 | 100 | 90 | 110 | | | |
| **Lab ID:** | G14030448-001AMSD | Sample Matrix Spike Duplicate | | | | Run: DIONEX-IC1_140325A | | | 03/25/14 17:08 | |
| Chloride | | 202 | mg/L | 1.0 | 99 | 90 | 110 | 0.4 | 20 | |
| **Method:** | **E300.0** | | | | | | | | Analytical Run: DIONEX-IC1_140326A | |
| **Lab ID:** | ICV/LCS-W | Initial Calibration Verification Standard | | | | | | | 03/26/14 10:44 | |
| Sulfate | | 39.7 | mg/L | 1.0 | 99 | 90 | 110 | | | |
| **Method:** | **E300.0** | | | | | | | | Batch: R210899 | |
| **Lab ID:** | ICB | Method Blank | | | | Run: DIONEX-IC1_140326A | | | 03/26/14 10:59 | |
| Sulfate | | ND | mg/L | 0.03 | | | | | | |
| **Lab ID:** | LFB | Laboratory Fortified Blank | | | | Run: DIONEX-IC1_140326A | | | 03/26/14 11:14 | |
| Sulfate | | 40.1 | mg/L | 1.0 | 102 | 90 | 110 | | | |
| **Lab ID:** | G14030489-001AMS | Sample Matrix Spike | | | | Run: DIONEX-IC1_140326A | | | 03/26/14 11:45 | |
| Sulfate | | 198 | mg/L | 1.0 | 101 | 90 | 110 | | | |
| **Lab ID:** | G14030489-001AMSD | Sample Matrix Spike Duplicate | | | | Run: DIONEX-IC1_140326A | | | 03/26/14 12:00 | |
| Sulfate | | 199 | mg/L | 1.0 | 101 | 90 | 110 | 0.3 | 20 | |

**Qualifiers:**

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

# QA/QC Summary Report

Prepared by Gillette, WY Branch

**Client:** Cirque Resources LP
**Project:** Not Indicated

**Report Date:** 04/10/14
**Work Order:** G14030467

| Analyte | | Result | Units | RL | %REC | Low Limit | High Limit | RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| **Method:** | **E300.0** | | | | | | | | Analytical Run: DIONEX-IC1_140408A | |
| **Lab ID:** | **ICV/LCS-W** | Initial Calibration Verification Standard | | | | | | | 04/08/14 11:16 | |
| Chloride | | 39.7 | mg/L | 1.0 | 99 | 90 | 110 | | | |
| **Method:** | **E300.0** | | | | | | | | Batch: R211160 | |
| **Lab ID:** | **ICB** | Method Blank | | | | Run: DIONEX-IC1_140408A | | | 04/08/14 11:31 | |
| Chloride | | ND | mg/L | 0.02 | | | | | | |
| **Lab ID:** | **LFB** | Laboratory Fortified Blank | | | | Run: DIONEX-IC1_140408A | | | 04/08/14 11:45 | |
| Chloride | | 38.0 | mg/L | 1.0 | 97 | 90 | 110 | | | |
| **Lab ID:** | **G14040176-001AMS** | Sample Matrix Spike | | | | Run: DIONEX-IC1_140408A | | | 04/08/14 12:13 | |
| Chloride | | 214 | mg/L | 1.0 | 101 | 90 | 110 | | | |
| **Lab ID:** | **G14040176-001AMSD** | Sample Matrix Spike Duplicate | | | | Run: DIONEX-IC1_140408A | | | 04/08/14 12:27 | |
| Chloride | | 214 | mg/L | 1.0 | 102 | 90 | 110 | 0.2 | 20 | |
| **Method:** | **E300.0** | | | | | | | | Analytical Run: DIONEX-IC1_140409A | |
| **Lab ID:** | **ICV/LCS-W** | Initial Calibration Verification Standard | | | | | | | 04/09/14 11:30 | |
| Sulfate | | 39.9 | mg/L | 1.0 | 100 | 90 | 110 | | | |
| **Method:** | **E300.0** | | | | | | | | Batch: R211197 | |
| **Lab ID:** | **ICB** | Method Blank | | | | Run: DIONEX-IC1_140409A | | | 04/09/14 11:44 | |
| Sulfate | | ND | mg/L | 0.03 | | | | | | |
| **Lab ID:** | **LFB** | Laboratory Fortified Blank | | | | Run: DIONEX-IC1_140409A | | | 04/09/14 11:58 | |
| Sulfate | | 39.1 | mg/L | 1.0 | 100 | 90 | 110 | | | |
| **Lab ID:** | **G14040231-004AMS** | Sample Matrix Spike | | | | Run: DIONEX-IC1_140409A | | | 04/10/14 01:38 | |
| Sulfate | | 4630 | mg/L | 10 | 99 | 90 | 110 | | | |
| **Lab ID:** | **G14040231-004AMSD** | Sample Matrix Spike Duplicate | | | | Run: DIONEX-IC1_140409A | | | 04/10/14 01:52 | |
| Sulfate | | 4620 | mg/L | 10 | 98 | 90 | 110 | 0.2 | 20 | |

**Qualifiers:**

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

# QA/QC Summary Report

Prepared by Billings, MT Branch

**Client:** Cirque Resources LP **Report Date:** 04/04/14

**Project:** Not Indicated **Work Order:** G14030467

| Analyte | Count | Result | Units | RL | %REC | Low Limit | High Limit | RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| **Method:** E200.7 | | | | | | | | | Analytical Run: ICP203-B_140326A | |
| **Lab ID:** ICV | 7 | Continuing Calibration Verification Standard | | | | | | | 03/26/14 11:35 | |
| Barium | | 2.53 | mg/L | 0.10 | 101 | 95 | 105 | | | |
| Calcium | | 25.7 | mg/L | 1.0 | 103 | 95 | 105 | | | |
| Iron | | 2.56 | mg/L | 0.020 | 102 | 95 | 105 | | | |
| Magnesium | | 25.8 | mg/L | 1.0 | 103 | 95 | 105 | | | |
| Potassium | | 25.5 | mg/L | 1.0 | 102 | 95 | 105 | | | |
| Sodium | | 25.6 | mg/L | 1.0 | 103 | 95 | 105 | | | |
| Strontium | | 2.52 | mg/L | 0.10 | 101 | 95 | 105 | | | |
| **Method:** E200.7 | | | | | | | | | Batch: R221275 | |
| **Lab ID:** MB-6500DIS140326A | 7 | Method Blank | | | | Run: ICP203-B_140326A | | | 03/26/14 11:59 | |
| Barium | | ND | mg/L | 0.0005 | | | | | | |
| Calcium | | ND | mg/L | 0.01 | | | | | | |
| Iron | | ND | mg/L | 0.004 | | | | | | |
| Magnesium | | ND | mg/L | 0.003 | | | | | | |
| Potassium | | ND | mg/L | 0.08 | | | | | | |
| Sodium | | ND | mg/L | 0.03 | | | | | | |
| Strontium | | ND | mg/L | 0.0002 | | | | | | |
| **Lab ID:** LFB-6500DIS140326A | 7 | Laboratory Fortified Blank | | | | Run: ICP203-B_140326A | | | 03/26/14 12:02 | |
| Barium | | 0.985 | mg/L | 0.10 | 98 | 85 | 115 | | | |
| Calcium | | 49.9 | mg/L | 1.0 | 100 | 85 | 115 | | | |
| Iron | | 4.98 | mg/L | 0.020 | 100 | 85 | 115 | | | |
| Magnesium | | 52.1 | mg/L | 1.0 | 104 | 85 | 115 | | | |
| Potassium | | 50.4 | mg/L | 1.0 | 101 | 85 | 115 | | | |
| Sodium | | 50.8 | mg/L | 1.0 | 102 | 85 | 115 | | | |
| Strontium | | 1.05 | mg/L | 0.10 | 105 | 85 | 115 | | | |
| **Lab ID:** B14031851-010BMS2 | 7 | Sample Matrix Spike | | | | Run: ICP203-B_140326A | | | 03/26/14 13:15 | |
| Barium | | 1.01 | mg/L | 0.050 | 97 | 70 | 130 | | | |
| Calcium | | 154 | mg/L | 1.0 | 91 | 70 | 130 | | | |
| Iron | | 4.88 | mg/L | 0.020 | 98 | 70 | 130 | | | |
| Magnesium | | 125 | mg/L | 1.0 | 100 | 70 | 130 | | | |
| Potassium | | 56.0 | mg/L | 1.0 | 101 | 70 | 130 | | | |
| Sodium | | 380 | mg/L | 1.0 | | 70 | 130 | | | A |
| Strontium | | 2.85 | mg/L | 0.010 | 101 | 70 | 130 | | | |
| **Lab ID:** B14031851-010BMSD | 7 | Sample Matrix Spike Duplicate | | | | Run: ICP203-B_140326A | | | 03/26/14 13:19 | |
| Barium | | 1.03 | mg/L | 0.050 | 99 | 70 | 130 | 1.6 | 20 | |
| Calcium | | 159 | mg/L | 1.0 | 101 | 70 | 130 | 3.0 | 20 | |
| Iron | | 5.01 | mg/L | 0.020 | 100 | 70 | 130 | 2.6 | 20 | |
| Magnesium | | 129 | mg/L | 1.0 | 108 | 70 | 130 | 3.0 | 20 | |
| Potassium | | 57.5 | mg/L | 1.0 | 104 | 70 | 130 | 2.7 | 20 | |
| Sodium | | 396 | mg/L | 1.0 | | 70 | 130 | 4.0 | 20 | A |
| Strontium | | 2.97 | mg/L | 0.010 | 112 | 70 | 130 | 3.9 | 20 | |

**Qualifiers:**

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

A - The analyte level was greater than four times the spike level. In accordance with the method % recovery is not calculated.

# QA/QC Summary Report

Prepared by Billings, MT Branch

**Client:** Cirque Resources LP
**Report Date:** 04/04/14
**Project:** Not Indicated
**Work Order:** G14030467

| Analyte | Count | Result | Units | RL | %REC | Low Limit | High Limit | RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| **Method:** E200.7 | | | | | | | | | Analytical Run: ICP203-B_140327A | |
| **Lab ID:** ICV | 2 | Continuing Calibration Verification Standard | | | | | | | | 03/27/14 11:27 |
| Barium | | 2.45 | mg/L | 0.10 | 98 | 95 | 105 | | | |
| Iron | | 2.48 | mg/L | 0.020 | 99 | 95 | 105 | | | |
| **Method:** E200.7 | | | | | | | | | | Batch: 78528 |
| **Lab ID:** MB-78528 | 2 | Method Blank | | | | Run: ICP203-B_140327A | | | | 03/27/14 19:30 |
| Barium | | ND | mg/L | 0.0004 | | | | | | |
| Iron | | ND | mg/L | 0.004 | | | | | | |
| **Lab ID:** LCS-78528 | 2 | Laboratory Control Sample | | | | Run: ICP203-B_140327A | | | | 03/27/14 20:08 |
| Barium | | 0.505 | mg/L | 0.10 | 101 | 85 | 115 | | | |
| Iron | | 2.56 | mg/L | 0.020 | 102 | 85 | 115 | | | |
| **Lab ID:** B14031858-002BMS3 | 2 | Sample Matrix Spike | | | | Run: ICP203-B_140327A | | | | 03/27/14 20:24 |
| Barium | | 1.34 | mg/L | 0.050 | 109 | 70 | 130 | | | |
| Iron | | 2.99 | mg/L | 0.021 | 107 | 70 | 130 | | | |
| **Lab ID:** B14031858-002BMSD | 2 | Sample Matrix Spike Duplicate | | | | Run: ICP203-B_140327A | | | | 03/27/14 20:28 |
| Barium | | 1.28 | mg/L | 0.050 | 96 | 70 | 130 | 5.0 | 20 | |
| Iron | | 2.87 | mg/L | 0.021 | 102 | 70 | 130 | 4.1 | 20 | |
| **Lab ID:** B14031864-001CMS3 | 2 | Sample Matrix Spike | | | | Run: ICP203-B_140327A | | | | 03/27/14 21:11 |
| Barium | | 1.05 | mg/L | 0.050 | 103 | 70 | 130 | | | |
| Iron | | 3.22 | mg/L | 0.020 | 104 | 70 | 130 | | | |
| **Lab ID:** B14031864-001CMSD | 2 | Sample Matrix Spike Duplicate | | | | Run: ICP203-B_140327A | | | | 03/27/14 21:14 |
| Barium | | 1.01 | mg/L | 0.050 | 97 | 70 | 130 | 3.3 | 20 | |
| Iron | | 3.11 | mg/L | 0.020 | 100 | 70 | 130 | 3.5 | 20 | |

**Qualifiers:**

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

# QA/QC Summary Report

Prepared by Billings, MT Branch

**Client:** Cirque Resources LP
**Report Date:** 04/04/14
**Project:** Not Indicated
**Work Order:** G14030467

| Analyte | Count | Result | Units | RL | %REC | Low Limit | High Limit | RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| **Method:** E200.7 | | | | | | | | | Analytical Run: ICP203-B_140408A | |
| **Lab ID:** ICV | 4 | Continuing Calibration Verification Standard | | | | | | | 04/08/14 11:34 | |
| Calcium | | 25.1 | mg/L | 1.0 | 100 | 95 | 105 | | | |
| Magnesium | | 25.4 | mg/L | 1.0 | 102 | 95 | 105 | | | |
| Potassium | | 25.1 | mg/L | 1.0 | 100 | 95 | 105 | | | |
| Sodium | | 25.1 | mg/L | 1.0 | 101 | 95 | 105 | | | |
| **Method:** E200.7 | | | | | | | | | Batch: R221830 | |
| **Lab ID:** MB-6500DIS140408A | 4 | Method Blank | | | | Run: ICP203-B_140408A | | | 04/08/14 11:57 | |
| Calcium | | 0.3 | mg/L | 0.01 | | | | | | |
| Magnesium | | 0.009 | mg/L | 0.003 | | | | | | |
| Potassium | | ND | mg/L | 0.08 | | | | | | |
| Sodium | | ND | mg/L | 0.03 | | | | | | |
| **Lab ID:** LFB-6500DIS140408A | 4 | Laboratory Fortified Blank | | | | Run: ICP203-B_140408A | | | 04/08/14 12:01 | |
| Calcium | | 54.0 | mg/L | 1.0 | 107 | 85 | 115 | | | |
| Magnesium | | 54.9 | mg/L | 1.0 | 110 | 85 | 115 | | | |
| Potassium | | 53.8 | mg/L | 1.0 | 108 | 85 | 115 | | | |
| Sodium | | 53.9 | mg/L | 1.0 | 108 | 85 | 115 | | | |
| **Lab ID:** B14040244-004BMS2 | 4 | Sample Matrix Spike | | | | Run: ICP203-B_140408A | | | 04/08/14 12:28 | |
| Calcium | | 54.4 | mg/L | 1.0 | 109 | 70 | 130 | | | |
| Magnesium | | 55.0 | mg/L | 1.0 | 110 | 70 | 130 | | | |
| Potassium | | 54.4 | mg/L | 1.0 | 109 | 70 | 130 | | | |
| Sodium | | 54.5 | mg/L | 1.0 | 109 | 70 | 130 | | | |
| **Lab ID:** B14040244-004BMSD | 4 | Sample Matrix Spike Duplicate | | | | Run: ICP203-B_140408A | | | 04/08/14 12:32 | |
| Calcium | | 53.9 | mg/L | 1.0 | 108 | 70 | 130 | 0.8 | 20 | |
| Magnesium | | 54.5 | mg/L | 1.0 | 109 | 70 | 130 | 0.9 | 20 | |
| Potassium | | 54.1 | mg/L | 1.0 | 108 | 70 | 130 | 0.5 | 20 | |
| Sodium | | 54.1 | mg/L | 1.0 | 108 | 70 | 130 | 0.8 | 20 | |

**Qualifiers:**

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

# QA/QC Summary Report

Prepared by Billings, MT Branch

**Client:** Cirque Resources LP
**Report Date:** 04/04/14
**Project:** Not Indicated
**Work Order:** G14030467

| Analyte | Count | Result | Units | RL | %REC | Low Limit | High Limit | RPD | RPDLimit | Qual |
|---|---|---|---|---|---|---|---|---|---|---|
| **Method:** E200.8 | | | | | | | | | Analytical Run: ICPMS203-B_140327A | |
| **Lab ID:** QCS | 2 | Initial Calibration Verification Standard | | | | | | | | 03/27/14 18:32 |
| Manganese | | 0.251 | mg/L | 0.010 | 100 | 90 | 110 | | | |
| Strontium | | 0.0519 | mg/L | 0.10 | 104 | 90 | 110 | | | |
| **Method:** E200.8 | | | | | | | | | | Batch: 78528 |
| **Lab ID:** MB-78528 | 2 | Method Blank | | | | Run: ICPMS203-B_140327A | | | | 03/27/14 22:29 |
| Manganese | | 0.0001 | mg/L | 3E-05 | | | | | | |
| Strontium | | ND | mg/L | 2E-05 | | | | | | |
| **Lab ID:** B14031858-002BMS3 | 2 | Sample Matrix Spike | | | | Run: ICPMS203-B_140327A | | | | 03/27/14 22:56 |
| Manganese | | 2.37 | mg/L | 0.0010 | 95 | 70 | 130 | | | |
| Strontium | | 0.593 | mg/L | 0.010 | 101 | 70 | 130 | | | |
| **Lab ID:** B14031858-002BMSD | 2 | Sample Matrix Spike Duplicate | | | | Run: ICPMS203-B_140327A | | | | 03/27/14 23:01 |
| Manganese | | 2.33 | mg/L | 0.0010 | 93 | 70 | 130 | 1.6 | 20 | |
| Strontium | | 0.588 | mg/L | 0.010 | 100 | 70 | 130 | 0.7 | 20 | |
| **Lab ID:** LCS-78528 | 2 | Laboratory Control Sample | | | | Run: ICPMS203-B_140327A | | | | 03/28/14 01:14 |
| Manganese | | 2.47 | mg/L | 0.0010 | 99 | 85 | 115 | | | |
| Strontium | | 0.508 | mg/L | 0.010 | 102 | 85 | 115 | | | |
| **Lab ID:** B14031864-001CMS3 | 2 | Sample Matrix Spike | | | | Run: ICPMS203-B_140327A | | | | 03/28/14 01:18 |
| Manganese | | 2.46 | mg/L | 0.0010 | 97 | 70 | 130 | | | |
| Strontium | | 1.19 | mg/L | 0.010 | 99 | 70 | 130 | | | |
| **Lab ID:** B14031864-001CMSD | 2 | Sample Matrix Spike Duplicate | | | | Run: ICPMS203-B_140327A | | | | 03/28/14 01:23 |
| Manganese | | 2.44 | mg/L | 0.0010 | 96 | 70 | 130 | 0.6 | 20 | |
| Strontium | | 1.18 | mg/L | 0.010 | 97 | 70 | 130 | 0.7 | 20 | |

**Qualifiers:**

RL - Analyte reporting limit.

ND - Not detected at the reporting limit.

# Workorder Receipt Checklist

## Cirque Resources LP

## G14030467

Login completed by: Amanda Alley
Date Received: 3/24/2014
Reviewed by: BL2000\kscottruff
Received by: kls
Reviewed Date: 3/24/2014
Carrier name: Hand Del

| | | | |
|---|---|---|---|
| Shipping container/cooler in good condition? | Yes ☑ | No ☐ | Not Present ☐ |
| Custody seals intact on all shipping container(s)/cooler(s)? | Yes ☐ | No ☐ | Not Present ☑ |
| Custody seals intact on all sample bottles? | Yes ☐ | No ☐ | Not Present ☑ |
| Chain of custody present? | Yes ☑ | No ☐ | |
| Chain of custody signed when relinquished and received? | Yes ☑ | No ☐ | |
| Chain of custody agrees with sample labels? | Yes ☑ | No ☐ | |
| Samples in proper container/bottle? | Yes ☑ | No ☐ | |
| Sample containers intact? | Yes ☑ | No ☐ | |
| Sufficient sample volume for indicated test? | Yes ☑ | No ☐ | |
| All samples received within holding time? (Exclude analyses that are considered field parameters such as pH, DO, Res Cl, Sulfite, Ferrous Iron, etc.) | Yes ☑ | No ☐ | |
| Temp Blank received in all shipping container(s)/cooler(s)? | Yes ☑ | No ☐ | Not Applicable ☐ |
| Container/Temp Blank temperature: | 11.1°C No Ice | | |
| Water - VOA vials have zero headspace? | Yes ☐ | No ☐ | No VOA vials submitted ☑ |
| Water - pH acceptable upon receipt? | Yes ☑ | No ☐ | Not Applicable ☐ |

### Standard Reporting Procedures:

Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH, Dissolved Oxygen and Residual Chlorine, are qualified as being analyzed outside of recommended holding time.

Solid/soil samples are reported on a wet weight basis (as received) unless specifically indicated. If moisture corrected, data units are typically noted as -dry. For agricultural and mining soil parameters/characteristics, all samples are dried and ground prior to sample analysis.

### Contact and Corrective Action Comments:

None

# Chain of Custody and Analytical Request Record

Page ____ of ____

**PLEASE PRINT (Provide as much information as possible.)**

Page 60 of 63

| | | | |
|---|---|---|---|
| Company Name: Cirque Resources | Project Name, PWS, Permit, Etc. | Sample Origin State: | EPA/State Compliance: Yes ☐ No ☐ |
| Report Mail Address (Required): | Contact Name: Myron Mears 307-331-2272 Phone/Fax: Cell: | | Sampler: (Please Print) |
| ☐ No Hard Copy Email: | Invoice Contact & Phone: | Purchase Order: | Quote/Bottle Order: |

Invoice Address (Required):

☐ No Hard Copy Email:

Special Report/Formats:
☐ DW ☐ EDD/EDT (Electronic Data)
☐ POTW/WWTP Format:
☐ State: ____ ☐ LEVEL IV
☐ Other: ____ ☐ NELAC

Number of Containers
Sample Type: A Air W Water S Soils/Solids V Vegetation B Bioassay O Other DW - Drinking Water

ANALYSIS REQUESTED

Standard Turnaround (TAT)

RUSH

Contact ELI prior to **RUSH** sample submittal for charges and scheduling – See Instruction Page

Comments: Shipping charges to client in Cheyenne - $25.00

Shipped by: Hand
Cooler ID(s):
Receipt Temp 11.1 °C
On Ice: Y (N)
Custody Seal On Bottle Y N On Cooler Y N
Intact Y N
Signature Match Y N

| | SAMPLE IDENTIFICATION (Name, Location, Interval, etc.) | Collection Date | Collection Time | MATRIX | SEE ATTACHED |
|---|---|---|---|---|---|
| 1 | Rosemary 31-3-16H | 3/22/14 | 0900 | 2W | X |
| 2 | Warren 17-1CH | 3/21/14 | 1145 | 2W | X |
| 3 | Dewey 7-9-1CH | 3/21/14 | 1130 | 2W | X |
| 4 | Rim Rock 33-4-6-2CH | 3/21/14 | 1630 | 2W | X |
| 5 | Gaviota 35-12-1CH | 3/21/14 | 1515 | 2W | X |
| 6 | Rosemary 31-3-16H | 3/22/14 | 0900 | Oil | X |
| 7 | Warren 17-1CH | 3/21/14 | 1145 | Oil | X |
| 8 | Dewey 7-9-1CH | 3/21/14 | 1130 | Oil | X |
| 9 | Rim Rock 33-4-6-2CH | 3/21/14 | 1646 | Oil | X |
| 10 | Gaviota 35-12-1CH | 3/21/14 | 1515 | Oil | X |

LABORATORY USE ONLY
LF
LF
LF
LF
LF
4030467

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**Custody Record MUST be Signed**

| | | | | | |
|---|---|---|---|---|---|
| Relinquished by (print): Jamie Means | Date/Time: 3/24/14 | Signature: Jamie Means | Received by (print): | Date/Time: | Signature: |
| Relinquished by (print): | Date/Time: | Signature: | Received by (print): | Date/Time: | Signature: |
| | | | Received by Laboratory: | Date/Time: 3/24/14 1310 | Signature: |

Sample Disposal: Return to Client: ____ Lab Disposal: ____

In certain circumstances, samples submitted to Energy Laboratories, Inc. may be subcontracted to other certified laboratories in order to complete the analysis requested.
This serves as notice of this possibility. All sub-contract data will be clearly notated on your analytical report.
Visit our web site at www.energylab.com for additional information, downloadable fee schedule, forms, and links.

14030467

| Test |
| --- |
| Bottom Sediment & Water |
| Gravity, API |
| Gravity, Specific |
| Hydrocarbon Identification |
| Hempel Distillation, Pressure |
| Hempel Distillation, Specific Gravities |
| Hempel Distillation, Volumes |
| Pour Point |
| Total Sulfur in Oil |
| Viscosity |
| Viscosity |
| Viscosity |
| Metals by ICP/ICPMS, Dissolved |
| Metals by ICP/ICPMS, Total |
| Alkalinity |
| QA Calculations |
| Conductivity |
| Sample Filtering |
| E300.0 Anions |
| pH |
| Metals Preparation by EPA 200.2 |
| Resistivity |
| Services Provided by Lab |
| Solids, Total Dissolved — TDS |
| Solids, Total Dissolved - Calculated |

Total

Barium
Iron
manganese
Strontium

Dissolved

- Barium
- Iron
- Strontium
- Cal
- Mag
- Pot
- Sod

Devin Brown

Sr Operations Engineer

Cirque Resources

303-226-9509 (w)

303-349-0302 (c)

**Kasey Scott-Ruff**

**From:** Myron Means <myronmeans@gmail.com>
**Sent:** Thursday, March 20, 2014 12:57 PM
**To:** kscottruff@energylab.com
**Subject:** Fwd: Oil & Water analysis
**Attachments:** Chamois oil and water analysis 6_21_12.pdf

---------- Forwarded message ----------
From: **Devin Brown** <dbrown@cirqueresources.com>
Date: Thu, Mar 20, 2014 at 12:50 PM
Subject: Oil & Water analysis
To: "Myron Means (myronmeans@gmail.com)" <myronmeans@gmail.com>

Myron,

Attached is an example of the testing we want on the oil and water. And here are the same tests listed out.

**Multi-Chem Analytical Laboratory**
185 Johnny Clark Rd.
Longview, TX 75603

multi-chem
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Units of Measurement: **Standard**

## Water Analysis Report

| | | | |
|---|---|---|---|
| Production Company: | **SAMSON EXPLORATION LLC** | Sales Rep: | **Michael Slama** |
| Well Name: | **TALLOW 0433 10H,LARAMIE** | Lab Tech: | **Edith Payne** |
| Sample Point: | **Wellhead** | | |
| Sample Date: | **1/18/2017** | | |
| Sample ID: | **WA-346075** | | |

Scaling potential predicted using ScaleSoftPitzer from Brine Chemistry Consortium (Rice University)

### Sample Specifics

| | |
|---|---|
| Test Date: | 1/31/2017 |
| System Temperature 1 (°F): | 300 |
| System Pressure 1 (psig): | 3000 |
| System Temperature 2 (°F): | 69 |
| System Pressure 2 (psig): | 15 |
| Calculated Density (g/ml): | 1.0214 |
| pH: | 7.07 |
| Calculated TDS (mg/L): | 37951.07 |
| CO2 in Gas (%): | |
| Dissolved $CO_2$ (mg/L)): | 205.92 |
| $H_2S$ in Gas (%): | |
| H2S in Water (mg/L): | 0.00 |
| Tot. SuspendedSolids(mg/L): | |
| Corrosivity(LanglierSat.Indx) | 0.00 |
| Alkalinity: | |

### Analysis @ Properties in Sample Specifics

| *Cations* | *mg/L* | *Anions* | *mg/L* |
|---|---|---|---|
| Sodium (Na): | 10585.34 | Chloride (Cl): | 26000.00 |
| Potassium (K): | 39.19 | Sulfate ($SO_4$): | 1.00 |
| Magnesium (Mg): | 39.54 | Bicarbonate ($HCO_3$): | 756.40 |
| Calcium (Ca): | 354.77 | Carbonate ($CO_3$): | |
| Strontium (Sr): | 57.58 | Hydroxide(HO): | |
| Barium (Ba): | 17.49 | Acetic Acid ($CH_3COO$) | |
| Iron (Fe): | 25.30 | Propionic Acid ($C_2H_5COO$) | |
| Zinc (Zn): | 0.15 | Butanoic Acid ($C_3H_7COO$) | |
| Lead (Pb): | 0.51 | Isobutyric Acid ($(CH_3)_2CHCOO$) | |
| Ammonia $NH_3$: | | Fluoride (F): | |
| Manganese (Mn): | 0.42 | Bromine (Br): | |
| Aluminum (Al): | 0.13 | Silica ($SiO_2$): | 73.38 |
| Lithium (Li): | | Calcium Carbonate ($CaCO_3$): | |
| Boron (B): | 20.22 | Phosphates ($PO_4$): | 0.64 |
| Silicon (Si): | 34.30 | Oxygen ($O_2$): | |

Notes:

(PTB = Pounds per Thousand Barrels)

| | | Calcium Carbonate | | Barium Sulfate | | Iron Sulfide | | Iron Carbonate | | Gypsum CaSO4-2H2O | | Celestite SrSO4 | | Halite NaCl | | Zinc Sulfide | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°F) | PSI | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB |
| 69.00 | 15.00 | 0.56 | 44.72 | 0.00 | 0.00 | 0.00 | 0.00 | 1.11 | 16.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 95.00 | 347.00 | 0.57 | 45.53 | 0.00 | 0.00 | 0.00 | 0.00 | 1.21 | 16.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 120.00 | 678.00 | 0.68 | 55.25 | 0.00 | 0.00 | 0.00 | 0.00 | 1.38 | 17.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 146.00 | 1010.00 | 0.80 | 66.83 | 0.00 | 0.00 | 0.00 | 0.00 | 1.53 | 17.59 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 172.00 | 1342.00 | 0.95 | 79.94 | 0.00 | 0.00 | 0.00 | 0.00 | 1.68 | 17.83 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 197.00 | 1673.00 | 1.10 | 94.12 | 0.00 | 0.00 | 0.00 | 0.00 | 1.82 | 17.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 223.00 | 2005.00 | 1.27 | 108.83 | 0.00 | 0.00 | 0.00 | 0.00 | 1.95 | 18.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 249.00 | 2337.00 | 1.46 | 123.48 | 0.00 | 0.00 | 0.00 | 0.00 | 2.06 | 18.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 274.00 | 2668.00 | 1.65 | 137.55 | 0.00 | 0.00 | 0.00 | 0.00 | 2.17 | 18.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 300.00 | 3000.00 | 1.84 | 150.60 | 0.00 | 0.00 | 0.00 | 0.00 | 2.25 | 18.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Multi-Chem Analytical Laboratory**
185 Johnny Clark Rd.
Longview, TX 75603

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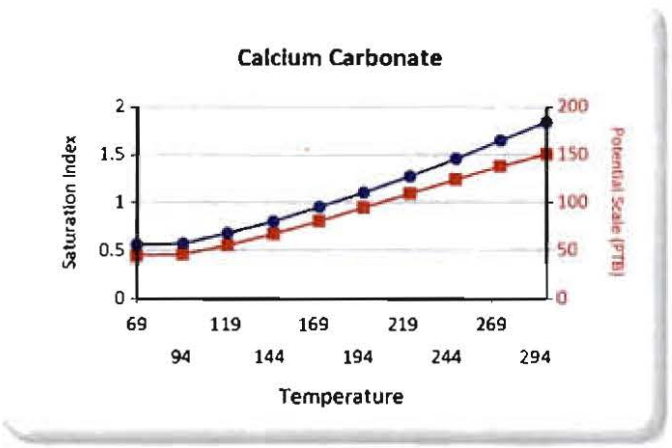
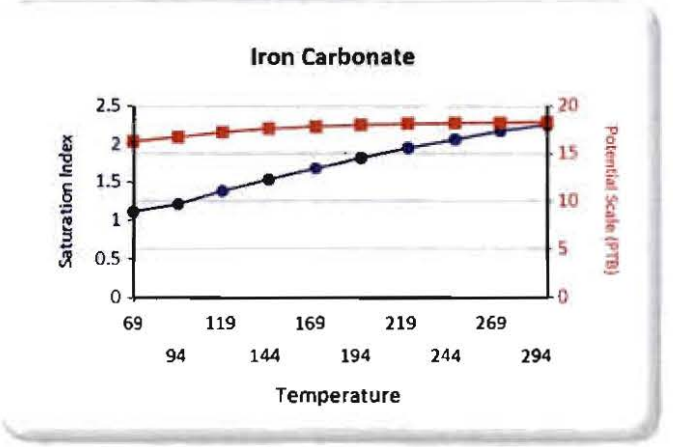
## Water Analysis Report

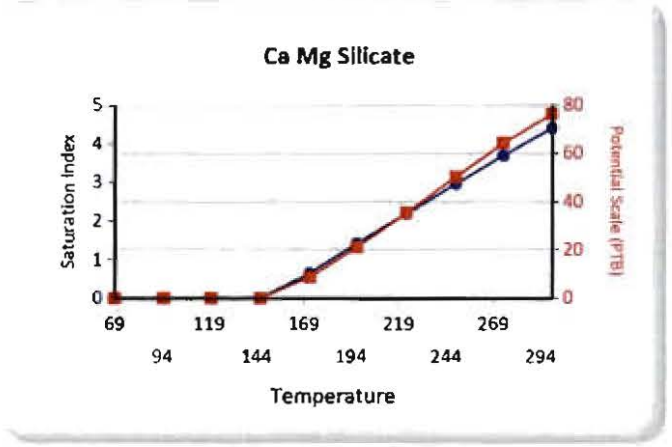
| | | Hemihydrate CaSO4*0.5H2O | | Anhydrate CaSO4 | | Calcium Fluoride | | Zinc Carbonate | | Lead Sulfide | | Mg Silicate | | Ca Mg Silicate | | Fe Silicate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°F) | PSI | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB |
| 69.00 | 15.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.49 | 15.80 |
| 95.00 | 347.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.83 | 16.55 |
| 120.00 | 678.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.70 | 17.97 |
| 146.00 | 1010.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.61 | 18.81 |
| 172.00 | 1342.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.49 | 5.14 | 0.64 | 8.58 | 6.55 | 19.26 |
| 197.00 | 1673.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.81 | 20.35 | 1.42 | 21.09 | 7.50 | 19.48 |
| 223.00 | 2005.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.10 | 36.75 | 2.19 | 35.32 | 8.45 | 19.59 |
| 249.00 | 2337.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.35 | 52.13 | 2.96 | 50.15 | 9.38 | 19.64 |
| 274.00 | 2668.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.01 | 0.00 | 0.00 | 5.56 | 64.25 | 3.70 | 64.22 | 10.29 | 19.66 |
| 300.00 | 3000.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 | 0.04 | 0.00 | 0.00 | 6.73 | 72.02 | 4.41 | 76.31 | 11.16 | 19.67 |

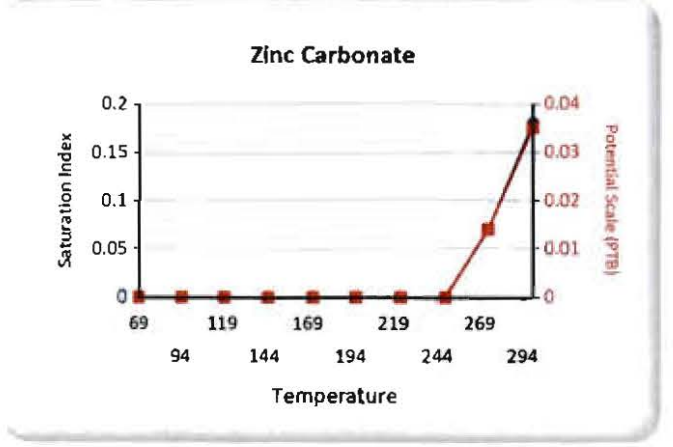
These scales have positive scaling potential under initial temperature and pressure: Calcium Carbonate Iron Carbonate Fe Silicate

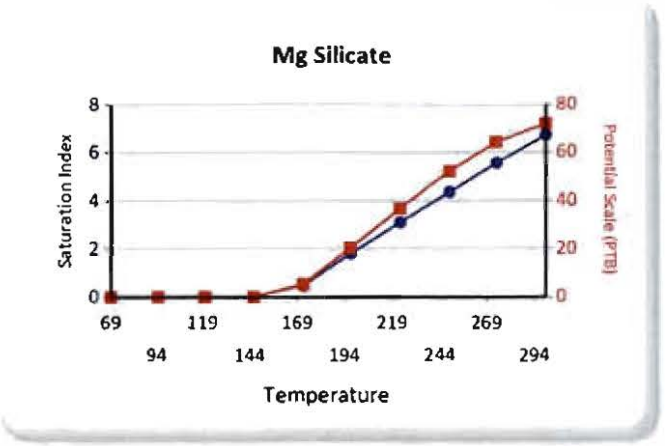
These scales have positive scaling potential under final temperature and pressure: Calcium Carbonate Iron Carbonate Zinc Carbonate Mg Silicate Ca Mg Silicate Fe Silicate

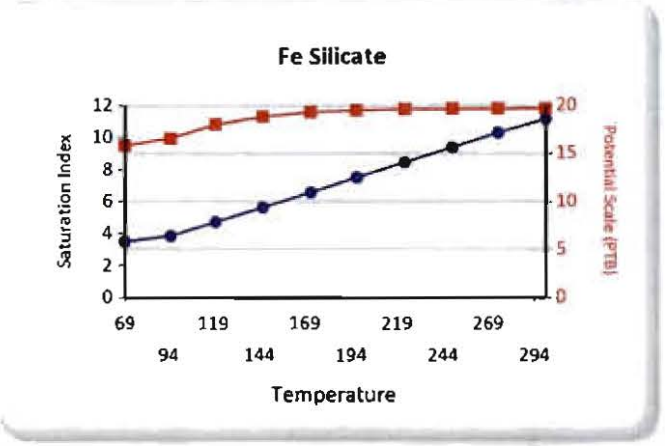



Mg Silicate
Saturation Index
Potential Scale (PTB)
Temperature
69
94
119
144
169
194
219
244
269
294


Fe Silicate
Saturation Index
Potential Scale (PTB)
Temperature
69
94
119
144
169
194
219
244
269
294

**Multi-Chem Analytical Laboratory**
185 Johnny Clark Rd.
Longview, TX 75603

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iits of Measurement: **Standard**

## Water Analysis Report

| | | | |
|---|---|---|---|
| Production Company: | **SAMSON EXPLORATION LLC** | Sales Rep: | **Michael Slama** |
| Well Name: | **TALLOW 0433 12H,LARAMIE** | Lab Tech: | **Edith Payne** |
| Sample Point: | **Wellhead** | | |
| Sample Date: | **1/18/2017** | | |
| Sample ID: | **WA-346076** | | |

Scaling potential predicted using ScaleSoftPitzer from Brine Chemistry Consortium (Rice University)

### Sample Specifics

| | |
|---|---|
| Test Date: | 1/31/2017 |
| System Temperature 1 (°F): | 300 |
| System Pressure 1 (psig): | 3000 |
| System Temperature 2 (°F): | 90 |
| System Pressure 2 (psig): | 15 |
| Calculated Density (g/ml): | 1.0198 |
| pH: | 7.07 |
| Calculated TDS (mg/L): | 35794.72 |
| CO2 in Gas (%): | |
| Dissolved $CO_2$ (mg/L)): | 95.04 |
| $H_2S$ in Gas (%): | |
| H2S in Water (mg/L): | 0.50 |
| Tot. SuspendedSolids(mg/L): | |
| Corrosivity(LanglierSat.Indx) | 0.00 |
| Alkalinity: | |

### Analysis @ Properties in Sample Specifics

| *Cations* | *mg/L* | *Anions* | *mg/L* |
|---|---|---|---|
| Sodium (Na): | 9475.63 | Chloride (Cl): | 25000.00 |
| Potassium (K): | 50.04 | Sulfate ($SO_4$): | 1.00 |
| Magnesium (Mg): | 36.21 | Bicarbonate ($HCO_3$): | 737.49 |
| Calcium (Ca): | 321.25 | Carbonate ($CO_3$): | |
| Strontium (Sr): | 56.59 | Hydroxide(HO): | |
| Barium (Ba): | 24.02 | Acetic Acid ($CH_3COO$) | |
| Iron (Fe): | 10.99 | Propionic Acid ($C_2HsCOO$) | |
| Zinc (Zn): | 0.01 | Butanoic Acid ($C_3H_7COO$) | |
| Lead (Pb): | 2.05 | Isobutyric Acid ($(CH_3)_2CHCOO$) | |
| Ammonia $NH_3$: | | Fluoride (F): | |
| Manganese (Mn): | 0.20 | Bromine (Br): | |
| Aluminum (Al): | 0.01 | Silica ($SiO_2$): | 79.24 |
| Lithium (Li): | | Calcium Carbonate ($CaCO_3$): | |
| Boron (B): | 20.15 | Phosphates ($PO_4$): | 1.41 |
| Silicon (Si): | 37.04 | Oxygen ($O_2$): | |

**otes:**

(PTB = Pounds per Thousand Barrels)

| | | Calcium Carbonate | | Barium Sulfate | | Iron Sulfide | | Iron Carbonate | | Gypsum CaSO4·2H2O | | Celestite SrSO4 | | Halite NaCl | | Zinc Sulfide | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°F) | PSI | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB |
| 90.00 | 15.00 | 0.63 | 50.42 | 0.00 | 0.00 | 1.30 | 0.44 | 0.94 | 6.92 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.18 | 0.00 |
| 113.00 | 347.00 | 0.62 | 49.22 | 0.00 | 0.00 | 1.10 | 0.42 | 1.00 | 7.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.71 | 0.00 |
| 137.00 | 678.00 | 0.73 | 58.79 | 0.00 | 0.00 | 1.05 | 0.42 | 1.14 | 7.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.41 | 0.00 |
| 160.00 | 1010.00 | 0.86 | 69.74 | 0.00 | 0.00 | 1.04 | 0.42 | 1.28 | 7.49 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.15 | 0.00 |
| 183.00 | 1342.00 | 0.99 | 81.76 | 0.00 | 0.00 | 1.07 | 0.42 | 1.41 | 7.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.94 | 0.00 |
| 207.00 | 1673.00 | 1.14 | 94.49 | 0.00 | 0.00 | 1.11 | 0.42 | 1.54 | 7.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.76 | 0.00 |
| 230.00 | 2005.00 | 1.30 | 107.49 | 0.00 | 0.00 | 1.19 | 0.43 | 1.65 | 7.78 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.60 | 0.00 |
| 253.00 | 2337.00 | 1.47 | 120.38 | 0.00 | 0.00 | 1.28 | 0.43 | 1.75 | 7.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.48 | 0.00 |
| 277.00 | 2668.00 | 1.64 | 132.76 | 0.00 | 0.00 | 1.38 | 0.44 | 1.84 | 7.85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.37 | 0.00 |
| 300.00 | 3000.00 | 1.82 | 144.33 | 0.00 | 0.00 | 1.50 | 0.45 | 1.92 | 7.88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.28 | 0.00 |

**Multi-Chem Analytical Laboratory**
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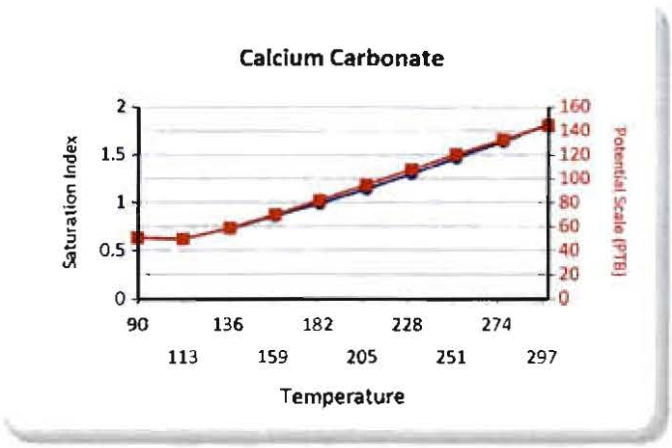
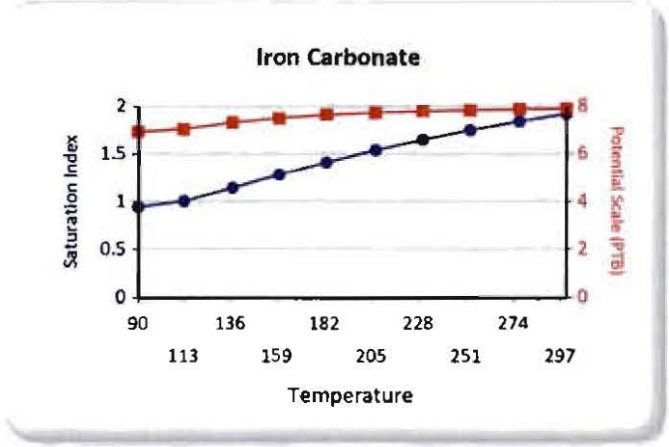
## Water Analysis Report

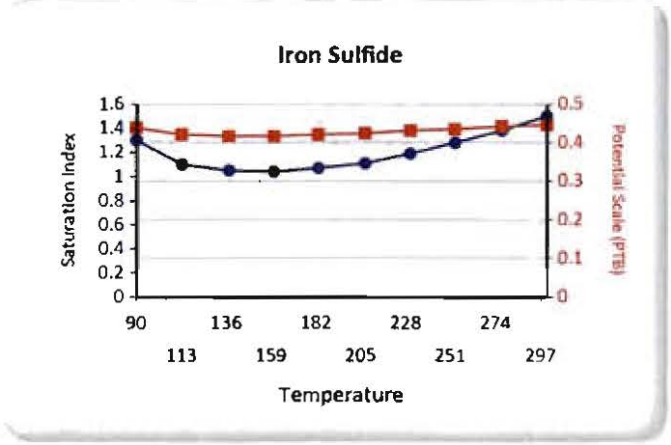
| | | Hemihydrate CaSO4~0.5H2O | | Anhydrate CaSO4 | | Calcium Fluoride | | Zinc Carbonate | | Lead Sulfide | | Mg Silicate | | Ca Mg Silicate | | Fe Silicate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°F) | PSI | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB |
| 90.00 | 15.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.64 | 0.83 | 0.00 | 0.00 | 0.00 | 0.00 | 3.37 | 7.46 |
| 113.00 | 347.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.90 | 0.83 | 0.00 | 0.00 | 0.00 | 0.00 | 3.53 | 7.57 |
| 137.00 | 678.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.37 | 0.83 | 0.00 | 0.00 | 0.00 | 0.00 | 4.35 | 8.02 |
| 160.00 | 1010.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.90 | 0.83 | 0.00 | 0.00 | 0.32 | 4.13 | 5.19 | 8.27 |
| 183.00 | 1342.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.50 | 0.83 | 1.12 | 11.84 | 1.03 | 14.55 | 6.05 | 8.41 |
| 207.00 | 1673.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.15 | 0.83 | 2.31 | 25.88 | 1.74 | 26.76 | 6.92 | 8.48 |
| 230.00 | 2005.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.85 | 0.83 | 3.47 | 39.96 | 2.44 | 40.14 | 7.78 | 8.51 |
| 253.00 | 2337.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.59 | 0.83 | 4.61 | 52.30 | 3.13 | 53.78 | 8.62 | 8.53 |
| 277.00 | 2668.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.36 | 0.83 | 5.70 | 61.45 | 3.80 | 66.70 | 9.44 | 8.54 |
| 300.00 | 3000.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.16 | 0.83 | 6.76 | 67.07 | 4.45 | 78.10 | 10.23 | 8.54 |

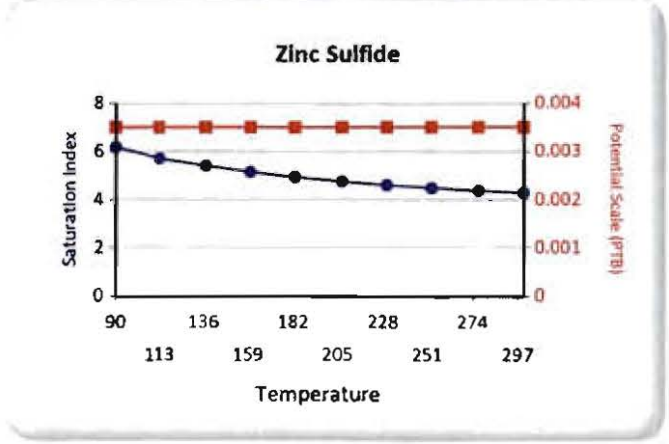
These scales have positive scaling potential under initial temperature and pressure: Calcium Carbonate Iron Sulfide Iron Carbonate Zinc Sulfide Lead Sulfide Fe Silicate

These scales have positive scaling potential under final temperature and pressure: Calcium Carbonate Iron Sulfide Iron Carbonate Zinc Sulfide Lead Sulfide Mg Silicate Ca Mg Silicate Fe Silicate



Multi-Chem Analytical Laboratory
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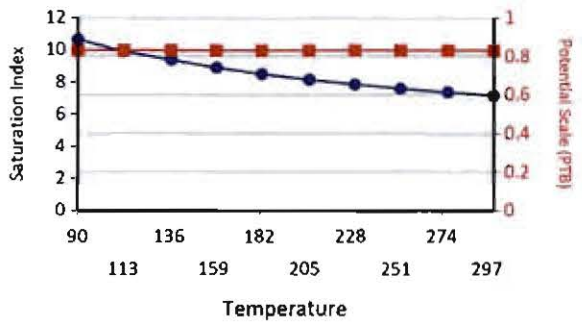
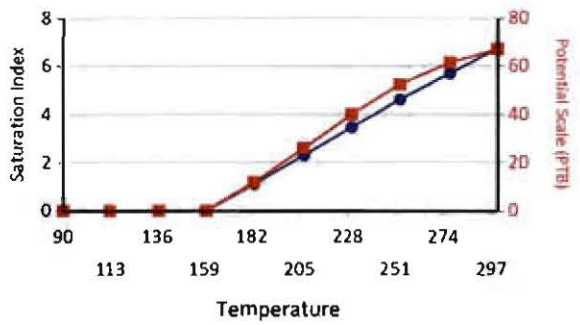
Water Analysis Report

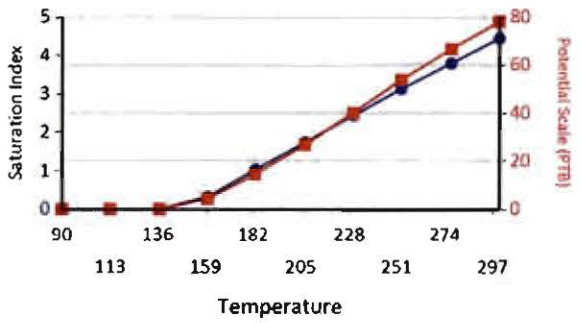
### Lead Sulfide



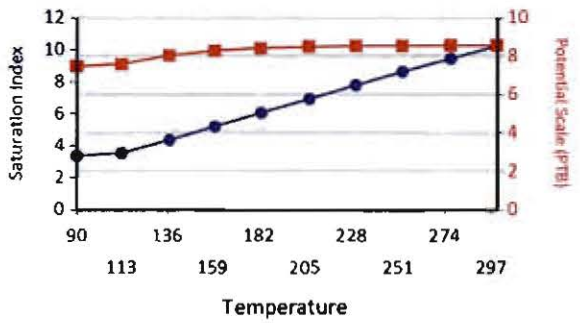

### Mg Silicate




### Ca Mg Silicate




### Fe Silicate



Multi-Chem Analytical Laboratory
185 Johnny Clark Rd.
Longview, TX 75603

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Units of Measurement: Standard

## Water Analysis Report

| | | | |
|---|---|---|---|
| Production Company: | SAMSON EXPLORATION LLC | Sales Rep: | Michael Slama |
| Well Name: | TALLOW 0916 10H,LARAMIE | Lab Tech: | Edith Payne |
| Sample Point: | Wellhead | | |
| Sample Date: | 1/18/2017 | | |
| Sample ID: | WA-346077 | | |

Scaling potential predicted using ScaleSoftPitzer from Brine Chemistry Consortium (Rice University)

| Sample Specifics | |
|---|---|
| Test Date: | 1/31/2017 |
| System Temperature 1 (°F): | 300 |
| System Pressure 1 (psig): | 3000 |
| System Temperature 2 (°F): | 99 |
| System Pressure 2 (psig): | 15 |
| Calculated Density (g/ml): | 1.0179 |
| pH: | 7.14 |
| Calculated TDS (mg/L): | 32780.59 |
| CO2 in Gas (%): | |
| Dissolved CO2 (mg/L)): | 118.80 |
| H2S in Gas (%): | |
| H2S in Water (mg/L): | 0.00 |
| Tot. SuspendedSolids(mg/L): | |
| Corrosivity(LanglierSat.Indx) | 0.00 |
| Alkalinity: | |

| Analysis @ Properties in Sample Specifics | | | |
|---|---|---|---|
| *Cations* | *mg/L* | *Anions* | *mg/L* |
| Sodium (Na): | 8671.69 | Chloride (Cl): | 23000.00 |
| Potassium (K): | 49.22 | Sulfate ($SO_4$): | 16.00 |
| Magnesium (Mg): | 31.70 | Bicarbonate ($HCO_3$): | 579.50 |
| Calcium (Ca): | 275.21 | Carbonate ($CO_3$): | |
| Strontium (Sr): | 49.29 | Hydroxide(HO): | |
| Barium (Ba): | 19.47 | Acetic Acid ($CH_3COO$) | |
| Iron (Fe): | 5.21 | Propionic Acid ($C_2H_5COO$) | |
| Zinc (Zn): | 0.01 | Butanoic Acid ($C_3H_7COO$) | |
| Lead (Pb): | 0.01 | Isobutyric Acid ($(CH_3)_2CHCOO$) | |
| Ammonia $NH_3$: | | Fluoride (F): | |
| Manganese (Mn): | 0.11 | Bromine (Br): | |
| Aluminum (Al): | 0.31 | Silica ($SiO_2$): | 83.17 |
| Lithium (Li): | | Calcium Carbonate ($CaCO_3$): | |
| Boron (B): | 22.28 | Phosphates ($PO_4$): | 0.28 |
| Silicon (Si): | 38.88 | Oxygen ($O_2$): | |

Notes:

(PTB = Pounds per Thousand Barrels)

| | | Calcium Carbonate | | Barium Sulfate | | Iron Sulfide | | Iron Carbonate | | Gypsum CaSO4·2H2O | | Celestite SrSO4 | | Halite NaCl | | Zinc Sulfide | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°F) | PSI | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB |
| 99.00 | 15.00 | 0.58 | 34.98 | 0.54 | 5.79 | 0.00 | 0.00 | 0.66 | 2.87 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 121.00 | 347.00 | 0.57 | 33.54 | 0.38 | 4.42 | 0.00 | 0.00 | 0.69 | 2.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 144.00 | 678.00 | 0.67 | 40.99 | 0.25 | 3.15 | 0.00 | 0.00 | 0.83 | 3.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 166.00 | 1010.00 | 0.79 | 49.52 | 0.16 | 2.05 | 0.00 | 0.00 | 0.96 | 3.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 188.00 | 1342.00 | 0.92 | 58.93 | 0.08 | 1.14 | 0.00 | 0.00 | 1.08 | 3.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 211.00 | 1673.00 | 1.06 | 68.93 | 0.03 | 0.43 | 0.00 | 0.00 | 1.19 | 3.52 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 233.00 | 2005.00 | 1.21 | 79.24 | 0.00 | 0.00 | 0.00 | 0.00 | 1.29 | 3.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 255.00 | 2337.00 | 1.37 | 89.52 | 0.00 | 0.00 | 0.00 | 0.00 | 1.39 | 3.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 278.00 | 2668.00 | 1.53 | 99.49 | 0.00 | 0.00 | 0.00 | 0.00 | 1.47 | 3.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 300.00 | 3000.00 | 1.69 | 108.87 | 0.00 | 0.00 | 0.00 | 0.00 | 1.53 | 3.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Multi-Chem Analytical Laboratory**
185 Johnny Clark Rd.
Longview, TX 75603

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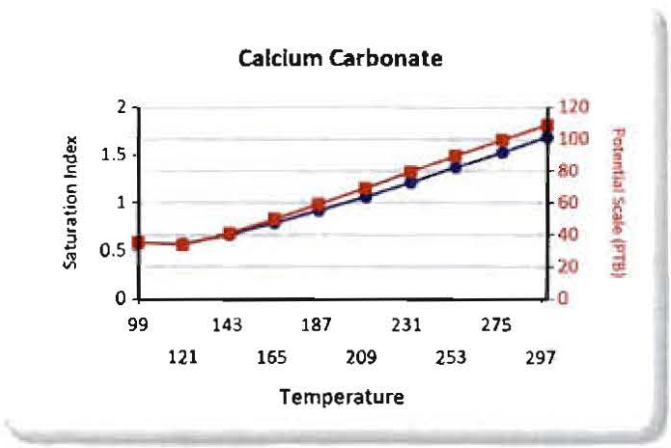
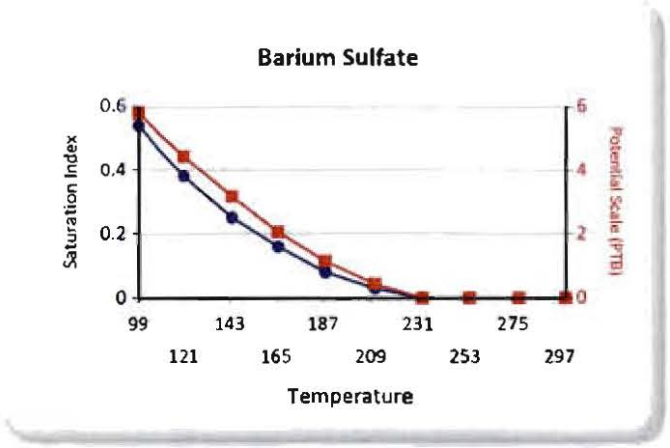
## Water Analysis Report

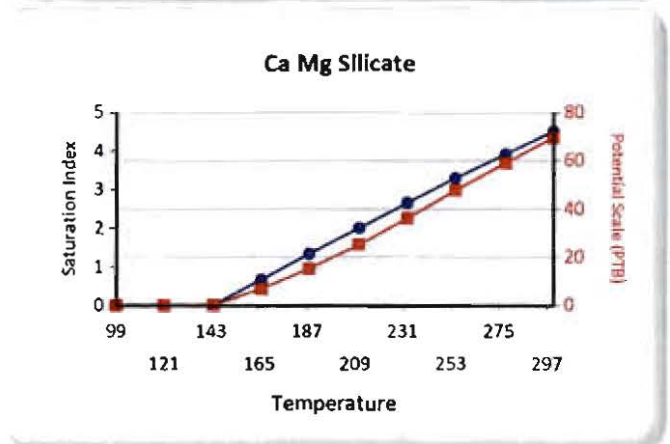
| | | Hemihydrate CaSO4~0.5H2O | | Anhydrate CaSO4 | | Calcium Fluoride | | Zinc Carbonate | | Lead Sulfide | | Mg Silicate | | Ca Mg Silicate | | Fe Silicate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°F) | PSI | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB | SI | PTB |
| 99.00 | 15.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.18 | 3.55 |
| 121.00 | 347.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.27 | 3.58 |
| 144.00 | 678.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.12 | 4.05 | 3.79 |
| 166.00 | 1010.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 | 3.65 | 0.67 | 6.84 | 4.86 | 3.91 |
| 188.00 | 1342.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.61 | 13.44 | 1.34 | 15.22 | 5.67 | 3.98 |
| 211.00 | 1673.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.72 | 24.42 | 2.01 | 25.10 | 6.47 | 4.01 |
| 233.00 | 2005.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.80 | 35.55 | 2.66 | 36.12 | 7.27 | 4.03 |
| 255.00 | 2337.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.86 | 45.51 | 3.30 | 47.64 | 8.05 | 4.04 |
| 278.00 | 2668.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.87 | 53.18 | 3.92 | 58.99 | 8.80 | 4.04 |
| 300.00 | 3000.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.84 | 58.15 | 4.51 | 69.52 | 9.52 | 4.05 |

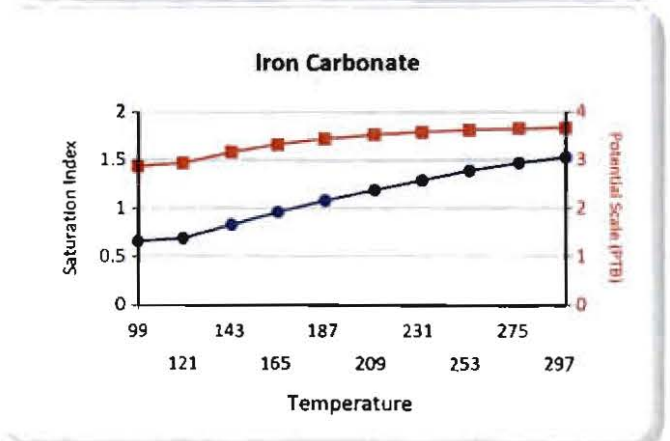
These scales have positive scaling potential under initial temperature and pressure: Calcium Carbonate Barium Sulfate Iron Carbonate Fe Silicate

These scales have positive scaling potential under final temperature and pressure: Calcium Carbonate Iron Carbonate Mg Silicate Ca Mg Silicate Fe Silicate



**Multi-Chem Analytical Laboratory**
185 Johnny Clark Rd.
Longview, TX 75603

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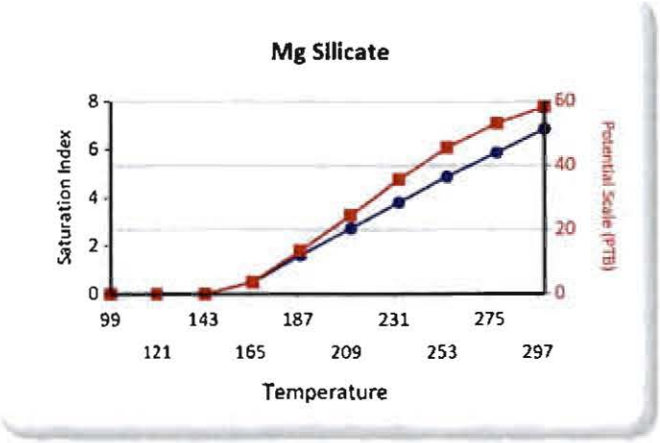
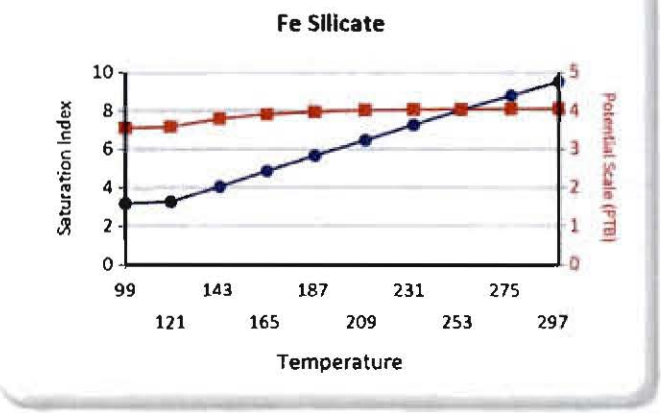
Water Analysis Report



Myron Means
Cirque Resources LP
475 17th St. Suite 1600
Denver, CO 80202

Date: October 1, 2014
Request Number: 33334
Date Received: 9-17-14
Matrix: Water

**REPORT OF ANALYSIS**

Lab Number: P3165
**Sample ID: Whitby 9-16-14 1645**

| **Cations** | Result, mg/L | Result, meq | Method | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Calcium | 559* | 27.89 | EPA 6010C | 9/18/2014 | CB |
| Magnesium | 70* | 5.76 | EPA 6010C | 9/18/2014 | CB |
| Sodium | 13,500* | 588 | EPA 6010C | 9/18/2014 | CB |
| Potassium | 61.7* | 1.58 | EPA 6010C | 9/18/2014 | CB |
| Dissolved Iron | 81.3 | 2.91 | EPA 6010C | 9/18/2014 | CB |
| Dissolved Barium | 53 | 0.77 | EPA 6010C | 9/18/2014 | CB |
| Cations Sum | -------- | 627 | | | |

| | | | | | |
|---|---|---|---|---|---|
| Dissolved Strontium | 106 | -------- | EPA 6010C | 9/18/2014 | CB |

**Anions**

| | | | | | |
|---|---|---|---|---|---|
| Bicarbonate (as CaC03) | 736 | 12.06 | EPA 310.1 | 9/23/2014 | DA |
| Hydroxide (as CaC03) | 0 | 0 | EPA 310.1 | 9/23/2014 | DA |
| Carbonate (as CaC03) | 0 | 0 | EPA 310.1 | 9/23/2014 | DA |
| Total Alkalinity (as CaC03) | 736 | 12.06 | EPA 310.1 | 9/23/2014 | DA |
| Chloride | 21,291 | 601 | ASTM D512 | 9/23/2014 | CB |
| Sulfate | 6.0 | 0.12 | EPA 375.3 | 9/22/2014 | CB |
| Anions Sum | -------- | 613 | | | |

| | | | | | |
|---|---|---|---|---|---|
| pH, std. units | 6.78 | ------- | EPA 150.1 | 9/23/2014 | DA |
| Total Dissolved Solids | 35,240 | ------- | EPA 160.1 | 9/23/2014 | DA |
| Conductivity | 67,500 | ------- | EPA 120.1 | 9/23/2014 | DA |

| | Result | Method |
|---|---|---|
| Langalier Saturation Index** | -0.47 | Calculated |

**LSI- Water is under saturated with respect to calcium carbonate. Under saturated water has a tendency to remove existing Calcium Carbonate protective coatings in pipelines and equipment. Water will cause corrosion.

*Results are the average of 2 runs

**WYOMING ANALYTICAL LABORATORIES, INC.**
1660 Harrison St. Wallaramie@wal-lab.com (307) 742-7995
Laramie, WY 82070 Fax: (307) 721-8956

Myron Means
Cirque Resources LP
475 17th St. Suite 1600
Denver, CO 80202

Date: October 1, 2014
Request Number: 33334
Date Received: 9-17-14
Matrix: Water

**REPORT OF ANALYSIS**

Lab Number: P3166
**Sample ID: Laguna 9-16-14 1800**

| **Cations** | Result, mg/L | Result, meq | Method | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Calcium | 446* | 22.26 | EPA 6010C | 9/18/2014 | CB |
| Magnesium | 58.8* | 4.84 | EPA 6010C | 9/18/2014 | CB |
| Sodium | 14,000* | 612 | EPA 6010C | 9/18/2014 | CB |
| Potassium | 104* | 2.66 | EPA 6010C | 9/18/2014 | CB |
| Dissolved Iron | 1.49* | 0.05 | EPA 6010C | 9/18/2014 | CB |
| Dissolved Barium | 45.7* | 0.67 | EPA 6010C | 9/18/2014 | CB |
| Cations Sum | ------- | 642 | | | |

| | | | | | |
|---|---|---|---|---|---|
| Dissolved Strontium | 91.4* | ------- | EPA 6010C | 9/18/2014 | CB |

| **Anions** | | | | | |
|---|---|---|---|---|---|
| Bicarbonate (as CaC03) | 560 | 9.18 | EPA 310.1 | 9/23/2014 | DA |
| Hydroxide (as CaC03) | 0 | 0 | EPA 310.1 | 9/23/2014 | DA |
| Carbonate (as CaC03) | 0 | 0 | EPA 310.1 | 9/23/2014 | DA |
| Total Alkalinity (as CaC03) | 560 | 9.18 | EPA 310.1 | 9/23/2014 | DA |
| Chloride | 21,939 | 619 | ASTM D512 | 9/23/2014 | CB |
| Sulfate | 16 | 0.33 | EPA 375.3 | 9/22/2014 | CB |
| Anions Sum | ------- | 628 | | | |

| | | | | | |
|---|---|---|---|---|---|
| pH, std. units | 7.12 | ------- | EPA 150.1 | 9/23/2014 | DA |
| Total Dissolved Solids | 36,890 | ------- | EPA 160.1 | 9/23/2014 | DA |
| Conductivity | 68,000 | ------- | EPA 120.1 | 9/23/2014 | DA |

| | Result | Method |
|---|---|---|
| Langalier Saturation Index** | -0.35 | Calculated |

**LSI- Water is under saturated with respect to calcium carbonate. Under saturated water has a tendency to remove existing Calcium Carbonate protective coatings in pipelines and equipment. Water will cause corrosion.

*Results are the average of 2 runs

Marte L. Ellis

End of Report
MLE/tab

Laboratory Manager

**WYOMING ANALYTICAL LABORATORIES, INC.**
1660 Harrison St. Laramie, WY 82070
Wallaramie@wal-lab.com
(307) 742-7995
Fax: (307) 721-8956

Myron Means
Cirque Resources LP
475 17th St. Suite 1600
Denver , CO 80202

Date: October 1, 2014
Request Number: 33334
Date Received: 9-17-14
Matrix: Water

**REPORT OF ANALYSIS**

Lab Number: P3165
**Sample ID: Whitby 9-16-14 1645**

| Time Sampled | Sample Date | Sulfur Reducing Bacteria, Approximately cfu/100ml | SRB Comments | Date & Time Started | Date & Time Ended |
|---|---|---|---|---|---|
| 1645 | 9-16-14 | 700,000 | BB/BT | 9-17-14 3:40pm | 9-19-14 2:05pm |

Lab Number: P3166
**Sample ID: Laguna 9-16-14 1800**

| Time Sampled | Sample Date | Sulfur Reducing Bacteria, Approximately cfu/100ml | SRB Comments | Date & Time Started | Date & Time Ended |
|---|---|---|---|---|---|
| 1800 | 9-16-14 | 700,000 | BT | 9-17-14 3:40pm | 9-19-14 2:05pm |

**SRB Comments**
BB: Dense Anaerobic consortium.
BT: Aerobic consortium.
FO: Foam Only

Mark L. Ellis

End of Report
MLE/tab

Laboratory Manager

**WYOMING ANALYTICAL LABORATORIES, INC.**
1660 Harrison St. Wallaramie@wal-lab.com (307) 742-7995
Laramie, WY 82070 Fax: (307) 721-8956

Myron Means
Cirque Resources LP
475 17th St. Suite 1600
Denver , CO 80202

Date: October 1, 2014
Request Number: 33334
Date Received: 9-17-14
Matrix: Oil & Water

**REPORT OF ANALYSIS**

Lab Number: P3165
**Sample ID: Whitby 9-16-14 1645 Water**

| | Result | Units | Method | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Sediment | 0.5 | % | D4007 | 9/17/2014 | CB |
| Water | < 0.1 | % | D4007 | 9/17/2014 | CB |

Lab Number: P3165
**Sample ID: Whitby 9-16-14 1645 Oil**

| | Result | Units | Method | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Total Sulfur | 0.329 | wt% | D2622 (XRF) | 09/30/14 | CW |
| Specific Gravity, 60F/60F | 0.918 | ------ | D1298 | 09/22/14 | DL |
| API | 22.7 | ------ | Calculated | 09/22/14 | DL |
| Pour Point | - 26.8 | $^{o}$C | D3227 | 09/23/14 | DL |
| Asphaltines | 0.4* | wt.% | D6560 M | 9/26-30/14 | CB |
| Paraffins | 17* | wt.% | Distillation | 9/17-30/14 | CB |
| Kinematic Viscosity @ 100$^{o}$F | 6.17 | cP | D445 | 09/22/14 | DL |
| Kinematic Viscosity @ 120$^{o}$F | 4.14 | cP | D445 | 09/22/14 | DL |

*Results are the average of 2 runs

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Denver , CO 80202

Date: October 1, 2014
Request Number: 33334
Date Received: 9-17-14
Matrix: Oil & Water

**REPORT OF ANALYSIS**

Lab Number: P3166
**Sample ID: Laguna 9-16-14 1800 Water**

| | Result | Units | Method | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Sediment | < 0.1 | % | D4007 | 9/17/2014 | CB |
| Water | 66 | % | D4007 | 9/17/2014 | CB |

Lab Number: P3166
**Sample ID: Laguna 9-16-14 1800 Oil**

| | Result | Units | Method | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Total Sulfur | 0.352 | wt% | D2622 (XRF) | 09/30/14 | CW |
| Specific Gravity, 60F/60F | 0.845 | ------ | D1298 | 09/22/14 | RB |
| API | 36.0 | ------ | Calculated | 09/22/14 | RB |
| Pour Point | - 24.7 | $^{o}$C | D3227 | 09/23/14 | RB |
| Asphaltines | 0.9 | wt.% | D6560 M | 9/26-30/14 | CB |
| Paraffins | 24 | wt.% | Distillation | 9/17-30/14 | CB |
| Kinematic Viscosity @ 100$^{o}$F | 5.29 | cP | D445 | 09/22/14 | DL |
| Kinematic Viscosity @ 120$^{o}$F | 3.64 | cP | D445 | 09/22/14 | DL |

*Results are the average of 2 runs

Marte L. Ellis

End of Report
MLE/tab

Laboratory Manager

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Myron Means
Cirque Resources LP
475 17th St. Suite 1600
Denver, CO 80202

Date: October 1, 2014
Request Number: 33334
Date Received: 9-17-14
Matrix: Oil & Water

## QUALITY CONTROL

| Water P3166 | Result | Dup. Result | RPD | RPD Limit | Lab control sample % | LCS Range % |
|---|---|---|---|---|---|---|
| Calcium, | 439 | 453 | 3.14 | 20 | 107 | 75-125 |
| Magnesium, mg/L | 58.0 | 59.6 | 2.72 | 20 | 109 | 75-125 |
| Sodium, mg/L | 13,890 | 14,240 | 2.49 | 20 | 105 | 75-125 |
| Potassium, mg/L | 103 | 105 | 1.92 | 20 | 106 | 75-125 |
| Dissolved Iron, mg/L | 1.48 | 1.49 | 18.2 | 20 | 107 | 75-125 |
| Dissolved Barium, mg/L | 44.7 | 46.6 | 4.16 | 20 | 110 | 75-125 |
| Dissolved Strontium, mg/L | 88.8 | 93.9 | 5.58 | 20 | 111 | 75-125 |

| | Reference | Expected | Value | % Recovery |
|---|---|---|---|---|
| Total Dissolved Solids, mg/L | Wal 4790 | 4790 | 4440 | 93 |
| Conductivity, mg/L | QCI-1096 | 1085 | 1087 | 100 |
| Sulfate, mg/L | WAL1047 | 1047 | 1013 | 97 |
| Total Alkalinity (as CaC03), mg/L | QCI-1096 | 490 | 492 | 100 |
| Chloride, mg/L | QCI-1096 | 299 | 302 | 101 |

| Oil P3166 | Result | Dup. Result | RPD | RPD Limit |
|---|---|---|---|---|
| Paraffins | 16 | 17 | 6.06 | 20 |
| Asphaltines | 0.4 | 0.4 | 0.00 | 20 |

End of QC Report
MLE/tab

Monte L. Ellis

Laboratory Manager

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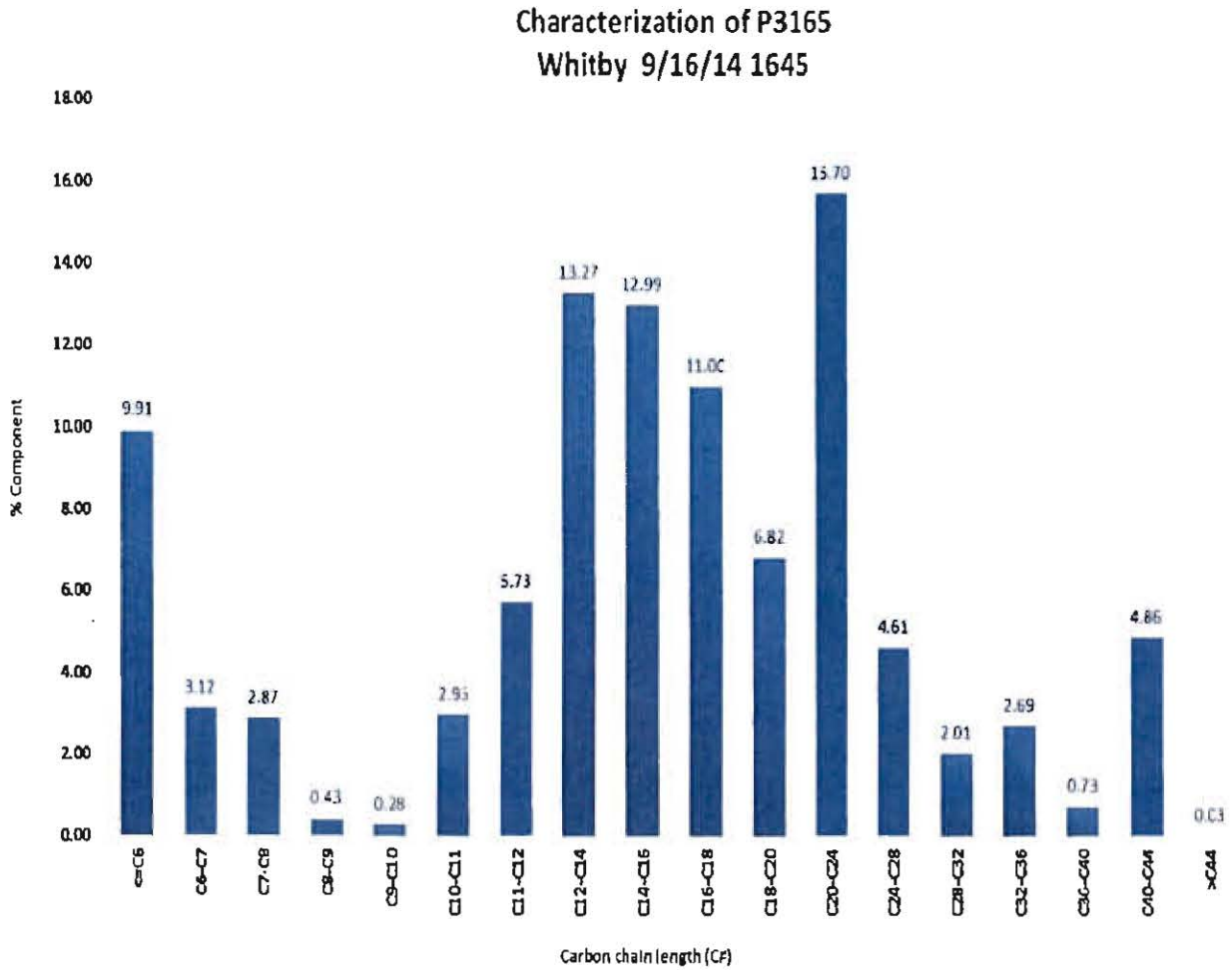
Denver, CO 80202

September 19 2014

Request 33334
page 1 of 2

Lab Id: P3165
Client Id: Whitby 9/16/14 1645





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475 17th St. Ste 1600
Denver, CO 80202

September 19 2014

Request 33334


Lab Id: P3165
Client Id: Whitby 9/16/14 1645

Simulated Distillation/Characterization D-2887

| Carbon # | Temp C | Temp F | % Component | Fraction | Fraction % | Cumulative % |
|---|---|---|---|---|---|---|
| <=C6 | <=69 | <=156 | 9.91 | Condensate | 9.91 | 9.91 |
| C6-C7 | 69-98 | 156-209 | 3.12 | | | 13.03 |
| C7-C8 | 98-126 | 209-258 | 2.87 | Naphtha | 6.42 | 15.90 |
| C8-C9 | 126-151 | 258-303 | 0.43 | | | 16.32 |
| C9-C10 | 151-174 | 303-345 | 0.28 | | | 16.61 |
| C10-C11 | 174-196 | 345-385 | 2.95 | | | 19.56 |
| C11-C12 | 196-216 | 385-421 | 5.73 | Kerosene | 22.24 | 25.29 |
| C12-C14 | 216-254 | 421-488 | 13.27 | | | 38.56 |
| C14-C16 | 254-287 | 488-548 | 12.99 | | | 51.55 |
| C16-C18 | 287-316 | 548-601 | 11.00 | Gas Oil | 30.81 | 62.55 |
| C18-C20 | 316-344 | 601-651 | 6.82 | | | 69.37 |
| C20-C24 | 344-391 | 651-736 | 15.70 | | | 85.07 |
| C24-C28 | 391-431 | 736-808 | 4.61 | | | 89.69 |
| C28-C32 | 431-466 | 808-870 | 2.01 | | | 91.69 |
| C32-C36 | 466-496 | 870-925 | 2.69 | Residual | 30.63 | 94.38 |
| C36-C40 | 496-522 | 925-972 | 0.73 | | | 95.11 |
| C40-C44 | 522-545 | 972-1013 | 4.86 | | | 99.97 |
| >C44 | >545 | >1013 | 0.03 | | | 100.00 |

| Test Parameter | Measured Value | Method |
|---|---|---|
| Initial Boiling Point F° | 148 | ASTM D-2887 |
| Finial Boiling Point F° | 938 | ASTM D-2887 |

Monte Ellis
Laboratory Manager

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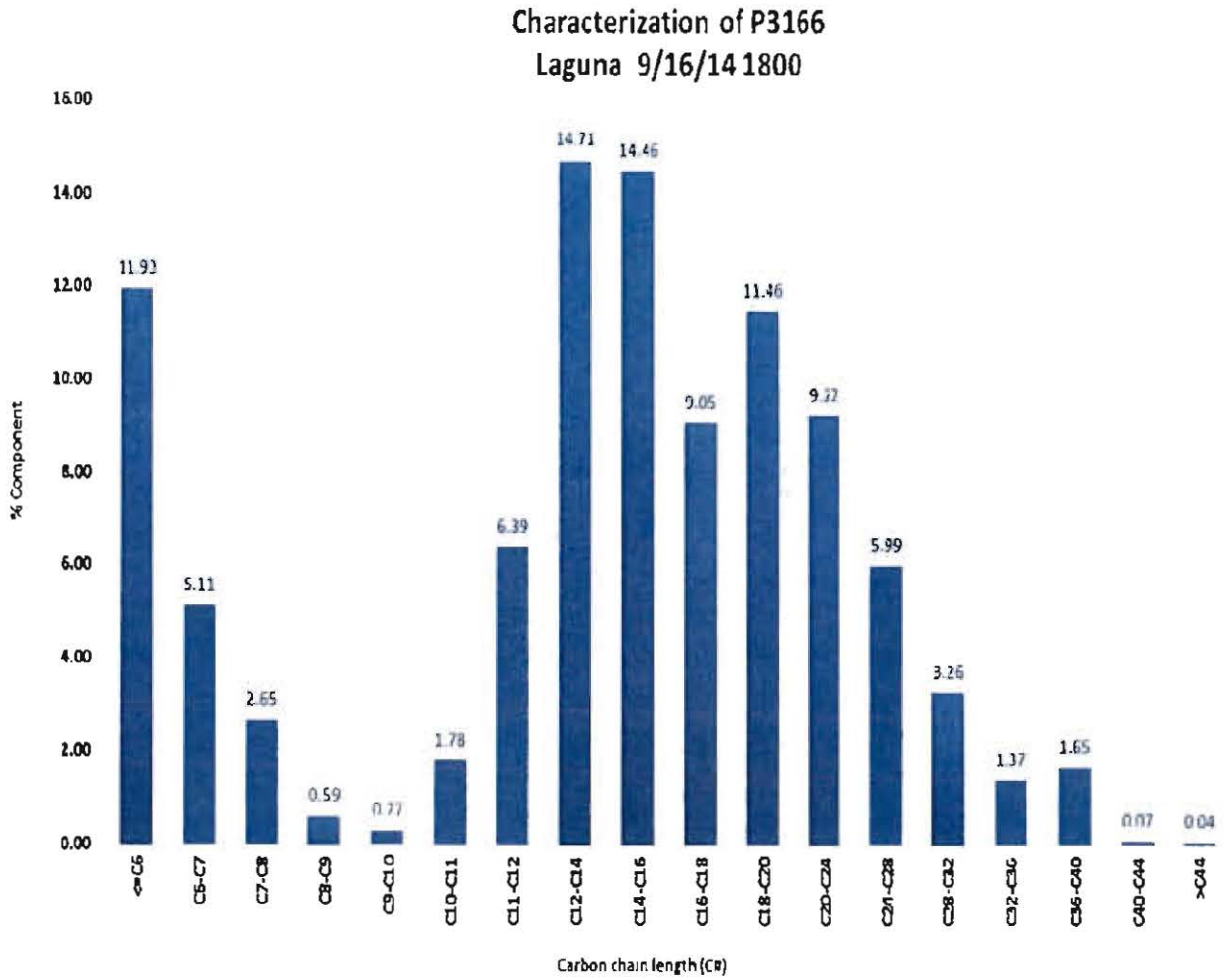
Cirque Resources LP
Myron Means
475 17th St. Ste 1600
Denver, CO 80202



Lab Id: P3166
Client Id: Laguna 9/16/14 1800

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Cirque Resources LP
Myron Means
475 17th St. Ste 1600
Denver, CO 80202



Lab Id: P3166
Client Id: Laugna 9-16-14 1800

Simulated Distillation/Characterization D-2887

| Carbon # | Temp C | Temp F | % Component | Fraction | Fraction % | Cumulative % |
|---|---|---|---|---|---|---|
| <=C6 | <=69 | <=156 | 11.93 | Condensate | 11.93 | 11.93 |
| C6-C7 | 69-98 | 156-209 | 5.11 | Naphtha | 8.34 | 17.04 |
| C7-C8 | 98-126 | 209-258 | 2.65 | | | 19.69 |
| C8-C9 | 126-151 | 258-303 | 0.59 | | | 20.28 |
| C9-C10 | 151-174 | 303-345 | 0.27 | Kerosene | 23.15 | 20.55 |
| C10-C11 | 174-196 | 345-385 | 1.78 | | | 22.33 |
| C11-C12 | 196-216 | 385-421 | 6.39 | | | 28.72 |
| C12-C14 | 216-254 | 421-488 | 14.71 | | | 43.43 |
| C14-C16 | 254-287 | 488-548 | 14.46 | Gas Oil | 34.97 | 57.89 |
| C16-C18 | 287-316 | 548-601 | 9.05 | | | 66.94 |
| C18-C20 | 316-344 | 601-651 | 11.46 | | | 78.40 |
| C20-C24 | 344-391 | 651-736 | 9.22 | Residual | 21.60 | 87.62 |
| C24-C28 | 391-431 | 736-808 | 5.99 | | | 93.62 |
| C28-C32 | 431-466 | 808-870 | 3.26 | | | 96.88 |
| C32-C36 | 466-496 | 870-925 | 1.37 | | | 98.25 |
| C36-C40 | 496-522 | 925-972 | 1.65 | | | 99.90 |
| C40-C44 | 522-545 | 972-1013 | 0.07 | | | 99.96 |
| >C44 | >545 | >1013 | 0.04 | | | 100.00 |

| Test Parameter | Measured Value | Method |
|---|---|---|
| Initial Boiling Point F° | 62 | ASTM D-2887 |
| Finial Boiling Point F° | 982 | ASTM D-2887 |

Monte Ellis
Laboratory Manager

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# APPENDIX C

Mineral, Working Interest, and Surface Owners within ½-Mile of Proposed Disposal Wells & Affidavit of Mailing

## Appendix C. Surface, Working Interst and Mineral Lease Owners

**Lease & Mineral Owners**

| Type | Leasehold Owner/Open Mineral Owner | Address (1) | Address (2) | City | State | Zip Code |
|---|---|---|---|---|---|---|
| fee | Anadarko Land Corp. | 1099 18th Street, Suite 1800 | Attn: WY/UT Regulatory Department | Denver | CO | 80202 |
| fee | Anadarko E&P Onshore LLC | 1099 18th Street, Suite 1800 | Attn: WY/UT Regulatory Department | Denver | CO | 80202 |
| fee | Occidental Petroleum Corporation | 1099 18th Street, Suite 1800 | Attn: WY/UT Regulatory Department | Denver | CO | 80202 |
| fee | EOG Resources, Inc. | 600 17th St., Suite 1000N | | Denver | CO | 80202 |
| fee | Iowa Land and Livestock Company | No address of record | | | | |
| fee | Parous Energy, LLC | P.O. Box 2547 | | Madison | MS | 39130 |
| fee | Samson Exploration, LLC | 110 West 7th Street, Suite 2000 | | Tulsa | OK | 74119 |
| fee | GBK Investments, LLC | P.O. Box 21470 | | Tulsa | OK | 74121-1470 |
| fee | Bell Livestock Company | No address of record | | | | |
| fee | Kaiser-Francis Mid-Continent Limited Partnership | 6733 S. Yale Avenue | | Tulsa | OK | 74136 |

**Surface Owners**

| Name1 | Name2 | Address | City | State | Zip Code | Legal |
|---|---|---|---|---|---|---|
| CHILD, WAYNE L REV TR ET AL | | 9816 CHILD RD | CHEYENNE | WY | 82009 | 15-65: SEC 29, 30, AND 31 |
| CHILD, MARK E LIV TR ET AL | | 9819 CHILD RD | CHEYENNE | WY | 82009 | 15-65: ALL SECS 20, 21, 22, 26; N1/2 SEC 27; N1/2 SEC 28 |
| STATE OF WYOMING | STATE LANDS | HERSCHLER BUILDING | CHEYENNE | WY | 82002 | 15-65: S1/2 S1/2 SEC 12; ALL SEC 16; LOTS 3, 4, E1/2 SW1/4, SE1/4, S |
| WARREN LIVESTOCK LLC | | 1961 TORRINGTON HWY | CHEYENNE | WY | 82009 | 15-65: ALL SECS 5,6,7,8,9; SW1/4, E1/2, SE1/4 NW1/4 SEC 10; ALL SEC 1 |

June 28, 2024

Tallgrass High Plains Carbon Storage, LLC
Attn: Mr. Kyle Quackenbush
4200 West 115th Street
Leawood, KS 66211

***Sent Via Email:*** *kyle.quackenbush@tallgrass.com*

RE: Tallgrass High Plains Carbon Storage, LLC, Eastern Wyoming Sequestration Hub
UIC Class VI Applications 2023-039 (Barberry I-1), 2023-040 (Cypress I-1), 2023-041 (Spirea I-1), 2023-263 (Old Barberry I-1), and 2023-264 (Azalea)
Laramie County, Wyoming

Dear Mr. Quackenbush,

The Wyoming Department of Environmental Quality, Water Quality Division (WDEQ/WQD) has reviewed the May 9, 2024 response to WDEQ's comments on above referenced Underground Injection Control (UIC) Program Class VI Permit Applications for the Tallgrass High Plains Carbon Storage, LLC (Tallgrass) Eastern Wyoming Sequestration Hub. Based on WDEQ's review of Tallgrass' response to WDEQ's comments, the following comments, associated with each permit application, were not addressed or require further clarification (unless noted otherwise, the comments pertain to all wells):

- **WDEQ Original General Comment No. 4**. *Please ensure consistent units are used throughout the application. For example, SSTVD is reported in some situations while MD is used in others. While SSTVD is acceptable, please also report the corresponding MD.*

  (June 27, 2024): Not addressed. Please see Specific Comment No. 22 below for further information.

- **WDEQ Original General Comment No. 5**. *Please ensure to use a consistent operator name throughout the application.*

  (June 27, 2024): Please provide an updated Form 1 as follows:
  - **Barberry**: Correct operator name from "Trailblazer High Plains Carbon Storage LLC." to "Tallgrass High Plains Carbon Storage LLC."
  - **Spirea**: Correct operator name from "Trailblazer High Plains Carbon Storage LLC." to "Tallgrass High Plains Carbon Storage LLC" and correct the conflicting Section, Township and Range information provided in Parts 1 and 2.

- **Azalea**: Correct operator name from "Trailblazer High Plains Carbon Storage LLC." to "Tallgrass High Plains Carbon Storage LLC."
- **Cypress and Old Barberry:** No further action required at this time.

- **WDEQ Original Specific Comment No. 5**. *In accordance with WWQR, Chapter 24, Section 10(b)(xix), please provide procedures for the formation testing programs to be done*
  - *in the Barberry I-1 and M-1.*
  - *in the Spirea I-1 and M-1.* (Note, this was **WDEQ Original Specific Comment No. 4** in the Spirea comment letter).
  - *in the Cypress I-1 and M-1.*
  - *in the Old Barberry I-1 and M-1.*
  - *in the Azalea I-1 and M-1.*

  (June 27, 2024): Additional information is needed in regard to shallow wells, including swab sampling procedures for wells not utilizing MDT. Additionally, please provide a demonstration that using the MDT minifrac tool to determine fracture gradient to establish LSIP is comparable to an injectivity or pump test, such as an SRT.

- **WDEQ Original Specific Comment No. 10**. *In accordance with WWQR, Chapter 24, Section 24(a)(ii)(M), the predicted rate of $CO_2$ trapping is required.*

  (June 27, 2024): Although graphs are provided, rates are not clearly identified. Please provide a numerical value for the rate at the end of the PISC.

- **WDEQ Original Specific Comment No. 11**. *In accordance with WWQR, Chapter 24, Section 26(a)(ii), financial assurance for each phase of the project is required including monitoring and testing; financial assurance for each phase is required to be reported separately from other financial assurance estimates.*

  (June 27, 2024):
  - **Barberry**: In Table 12, the subtotal for monitoring is incorrect. Please revise the monitoring subtotal to reflect the correct calculation.
  - **Spirea**: Please explain why the ERR Monte Carlo simulation for the Spirea returned different results than the other four wells which had results that appeared to be identical to each other. (Note, this was **WDEQ Original Specific Comment No. 10** in the Spirea comment letter).
  - **Old Barberry**: Please submit a Financial Assurance Demonstration Plan for the Old Barberry permit application.
  - **Azalea and Cypress**: No further action required at this time.

- **WDEQ Original Specific Comment No. 17.** *Section 4.4.2 Proposed Monitoring Well Casing and Cementing Programs of the permit application states "The well will be drilled through the Sundance and will penetrate the top of the Chugwater," whereas Section 4.5.2.1 Pre-plugging Procedures 2. Determination of bottomhole reservoir pressure states "The well is not expected to be perforated or open to any formation and the total depth at drilling and completion was to be above the containment layers for the Lyons sequestration reservoir."*

  (June 27, 2024): Please provide clarification as to when the monitoring well(s) will be drilled. In addition, any updates to construction designs are considered a minor permit modification and therefore, modified plans are required to be submitted to WDEQ for review and approval prior to drilling.

The following comments were not provided in the WDEQ January – March, 2024 Comments or were recently identified based on Tallgrass' May 9, 2024 response to WDEQ comments (unless noted otherwise, the comments pertain to all wells):

- **WDEQ June 27, 2024 Specific Comment No. 22:** Please provide measured depth values for all depths reported in the permit application. This data can be submitted as a table that includes the measured and subsea depths of all formations whose depths were reported only as subsea in the permit application, including the depths and ranges of depths given on

  - **Barberry:** pages 66, 69, 93, 95, and 102-103 of the permit application and pages B-14 and B-17 of Appendix B.
  - **Spirea:** pages 67, 70, 94, 96, 103 and 104 of the permit application and pages B-14 and B-17 of Appendix B.
  - **Cypress:** pages 67, 70, 94, 96, 103, and 104 of the permit application and page B-14 and B-17 of Appendix B.
  - **Old Barberry:** pages 67, 70, 94, 96, 103, and 104 of the permit application and pages B-14 and B-17 of Appendix B.
  - **Azalea:** pages 67, 70, 94, 96, 103 and 104 of the permit application and pages B-14 and B-17 of Appendix B.

- **WDEQ June 27, 2024 Specific Comment No. 23:** Please submit a discussion of how the dipole sonic tool was used to determine that open fractures are not transmissive, including a description of the depth of investigation of the dipole sonic tool.

- **WDEQ June 27, 2024 Specific Comment No. 24:** Please include in the monitoring plan that total cumulative volume injected will be reported.

- **WDEQ June 27, 2024 Specific Comment No. 25:** TDS concentrations can be determined through sample analysis or calculation from conductivity information available. Please provide additional information to support that the Amazon is not a USDW.

- **WDEQ June 27, 2024 Specific Comment No. 26 (Cypress and Old Barberry only):** Cypress M-2 was drilled as a strat test and was not completed as a monitoring well. As Cypress M-2 is located in the AoR, a review for whether corrective action is necessary is required. Please provide all information regarding drilling procedures, any construction activities completed on the monitoring well, plugging and abandonment procedures and final report.

- **WDEQ June 27, 2024 Specific Comment No. 27 (Cypress only):** Permit Application, Page 4, 2. Site and Facility Description and the updated Form 1 submitted with the Response to Comments dated May 10, 2024 both note that the proposed project will be located in the "***Southwestern corner of Wyoming***." Please revise all references to southwestern corner to southeastern corner.

Please provide a response to the above comments within thirty (30) days of the date of this letter. If Tallgrass wishes to expedite the review and response to comments process, WDEQ/WQD encourages Tallgrass to review the comments and contact the UIC Program to discuss the comments prior to submitting a response. If you have questions or would like to schedule a meeting to discuss the comments, please contact me at (307) 777-7072 or lily.barkau@wyo.gov.

Sincerely,



Lily R. Barkau, P.G.
Groundwater Section Manager
Water Quality Division
Wyoming Department of Environmental Quality

Attachments: 2024-0201_UIC_2023-039_Tallgrass-Barberry-I-1_App-Chklst_rev06262024
2024-0201_UIC_2023-041_Tallgrass-Spirea-I-1_App-Chklst_rev06262024
2024-0201_UIC_2023-040_Tallgrass-Cypress-I-1_ App-Chklst_rev06262024
2024-0201_UIC_2023-263_Tallgrass-Old_Barberry-I-1_App-Chklst_rev06262024
2024-0204_UIC_2023-264_Tallgrass-Azalea-I-1_App-Chklst_rev06262024

cc: Tyler Harris, P.G., - WDEQ/WQD
Katy Larson, UIC Program Coordinator, Tallgrass High Plains Carbon Storage, LLC
(katy.larson@tallgrass.com)

**WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY**
**WATER QUALITY DIVISION, UNDERGROUND INJECTION CONTROL PROGRAM**
**CARBON SEQUESTRATION, CLASS VI**
**Spirea I-1**
**UIC Permit No. 2023-041**
**WYS-021-00155**

| √ | REQUIRED ITEM | LOCATION IN APPLICATION | COMMENT | COMMENT ADDRESSED? | FINAL REVIEW |
|---|---|---|---|---|---|
| **GENERAL INFORMATION** | | | | | |
| X | Application Type (Conversion, Modification, New) | Page 1, #1 | New | | |
| X | A brief description of the nature of the business and the activities to be conducted that require the applicant to obtain a permit under this Chapter; (Chapter 24, Section 10(b)(i)) | Page 4, #2 | "The proposed Eastern Wyoming Sequestration Hub (EWS Hub) will be located in the southeastern corner of Wyoming, in Laramie County, Section 34, Township 13N, Range 63W. Additional documentation will be provided as available." Later sections of the application detail the exact location and amount of $CO_2$ to be injected. | | |
| X | The name, address, and telephone number of the operator, and the operator's ownership status and status as a federal, state, private, public, or other entity; (Chapter 24, Section 10(b)(ii)) | Page 3, #1 | All contact information provided. Limited Liability Corporation, privately owned company. | | |
| X | Up to four Standard Industrial Classification codes that best reflect the principal products or services provided by the facility; (Chapter 24, Section 10(b)(iii)) | Page 4, #3 | 4953 – Refuse systems (Nonhazardous water disposal sites) 4619 – Pipelines, not elsewhere classified | | |
| | The name, address, and telephone number of the facility; (Chapter 24, Section 10(b)(iv)) | Page 3, #1, | Not provided. In the absence of a physical address, please provide latitude and longitudinal coordinates and PLSS description. **Specific Comment No. 1.** In accordance with Wyoming Water Quality Rules (WWQR), Chapter 24, Section 10 (b)(iv), please provide a completed Permit Application Form 1, Section 1, General Information, specifying the Facility Location Address. A proposed PLSS location and latitude and longitude may be used in the absence of an actual street address. | Tallgrass May 9, 2024 Response to WDEQ's Comments. | |
| X | Whether the facility is located on Indian lands. (Chapter 24, Section 10(b)(v)) | Page 4, #5 Table 3.3 (p. 135) | Not located on Indian lands. | | |
| X | The location of the geologic sequestration project is identified by section, township, range, and county, noting which sections (if any) include Indian lands; (Chapter 24, Section 10(b)(v)) | Table 1.1 (p. 35) Figure 1.1 (p. 35) | Spirea I-1 Location: SWNW Section 34 T13N R63W, Laramie Co., 41.052367° -104.424469° Figure 1.1 Shows the entire project area. No part of the project area is on Indian lands. | | |
| X | Within the area of review, a listing and status of all permits or construction approvals associated with the geologic sequestration project received or applied for under any of the following programs or corresponding state programs: RCRA, UIC, NPDES, PSD, Nonattainment program under CAA, National Emissions Standards for Hazardous Air Pollutants pre-construction approval under CAA, Dredge and fill permitting program under CWA, other relevant environmental permits, including State permits (Chapter 24, Section 10(b)(vi)(A-G)) | Table 3.1 (p. 133) Table 3.2 (p. 134) | No other environmental permits are currently associated with this permit. Other permits that are deemed necessary as the project progresses, will be acquired. (Table 3.2). | | |
| X | Within the area of review, a list of other relevant permits associated with the geologic sequestration project that the applicant is required to obtain; (Chapter 24, Section 10(b)(vii)) | Table 3.1 (p. 133) Table 3.2 (p. 134) | Other permits that are deemed necessary as the project progresses, will be acquired. (Table 3.2). 5 other Class VI wells are associated with the project – 2023-235 (Juniper), 2023-040 (Cypress), 2023-041 (Spirea), 2023-263 (Old Barberry), 2023- | | |

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| | | | 039 (Barberry), including one to four monitoring wells associated with each permit (one deep, upper confining unit MW and up to 3 shallow aquifer MW). | | |
| X | A statement of whether the geologic sequestration project is within a state-approved water quality management plan area, a state-approved wellhead protection area or a state-approved source water protection area; (Chapter 24, Section 10(b)(viii)) | Page 4, #4<br>Figure 3.6 (p. 138) | | | |
| X | Pursuant to Wyoming Water Quality Rules (WWQR), Chapter 8, Section 6(c)(ii), the discharge of waste will not degrade or decrease the availability of mineral resources, including oil and gas. Therefore, prior to submitting an application to construct a UIC Class VI injection well, the WDEQ strongly encourages applicants to collaborate with nearby leases and mineral ownership owners to demonstrate that the proposed injection activities will present no damage to existing or future recovery of sub-surface minerals. Any permit challenge that is upheld by the WOGCC is grounds for the WDEQ to deny the issuance of the Class VI UIC permit. | Section 2.2.2.1 (pp. 63-64) | There is no known hydrocarbon production from formations below the Muddy J, approximately 1,175' above the Lyons within the project area. | | |
| | A map showing the injection well(s) for which a permit is sought and the applicable area of review, consistent with Section 13 of this Chapter;<br>• Within the area of review, the map shall list the number, or name and location of:<br>• All injection wells, producing wells, abandoned wells, plugged wells, dry holes, or deep stratigraphic boreholes;<br>• All state- or EPA-approved subsurface cleanup sites;<br>• All water quality management plan areas, wellhead protection areas, and source water protection areas;<br>• All surface bodies of water, springs, mines (surface and subsurface), quarries, and water wells;<br>• Other pertinent surface features, including structures intended for human occupancy;<br>• Roads; and<br>• State and Indian reservation boundaries;<br>(Chapter 24, Section 10(b)(ix)) | Figure 1.1 (p. 35)<br>Figure 3.4 (p. 136)<br>Figure 3.5 (p. 137)<br>Figure 3.6 (p. 138)<br>Table 3.4 (pp. 139-142) | Springs and water wells shown on Figure 3.4. All injection, producing, plugged, abandoned, dry holes displayed on Figure 3.5. Source water and wellhead protection areas shown on Figure 3.6. Table 3.4 lists all oil and gas wells in the AoR. State boundary is shown on all map figures. No Indian lands are present in the AoR.<br><br>Surface bodies of water and human occupied structures are not denoted on maps. Roads are present on satellite imagery but need to be highlighted<br><br>**Specific Comment No. 2.** In accordance with WWQR, Chapter 24, Section 10(b)(vi)(ix), please provide maps of the following or a statement that such entities do not exist within the AoR:<br><br>a. All state or EPA-approved cleanup sites<br>b. All surface bodies of water<br>c. Other pertinent surface features, including structures intended for human occupancy; | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 3 for the other four applications. | |
| X | Wyoming Conservation Executive Orders 2019-3 (Sage Grouse) and 2020-1 (Migration Corridor) | Page 2, Sections a and b | No portion of the project falls within SGCAs or Migration Corridors. | | |

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| X | Published notice of the application in a newspaper of general circulation in each county of the proposed operation is required. Published for four consecutive weeks and copy of the notice mailed to all surface owners, mineral claimants, mineral owners, lessees, and other owners of record of subsurface interest that are located within one mile of the proposed boundary of the geologic sequestration site. (W.S. 35-11-313(f)(ii)(N)) | | Affidavit of publishing received. | 12/27/23 – Affidavit of Mailing List | |
| X | A list of contacts for states or Tribes on Indian lands or territories (Chapter 24, Section 10(b)(xxxvi)) | Page 5, #6; Page 4, #5 | No part of the project on Indian lands. | | |
| X | Sections of permit applications that represent engineering work shall be sealed, signed, and dated by a licensed professional engineer as required by W.S. § 33-29-601. (Chapter 24, Section 10(e)) | Page 10 | Stamped by Ray Clanton, PE #17641. | | |
| X | Sections of permit applications that represent geologic work shall be sealed, signed, and dated by a licensed professional geologist as required by W.S. § 33-41-115. (Chapter 24, Section 10(f)) | Page 9 | Stamped by Eric White, PG #4303. | | |
| X | All applications for permits, reports, or information submitted to the Administrator shall be signed by a responsible corporate officer. (Chapter 24, Section 10(c)) | Page 6, #9 | Signed by Kyle Quackenbush, Segment President and VP – Liquids (Crude Oil and CO2), Tallgrass. | | |
| X | The application shall contain the following certification by the responsible corporate officer signing the application:<br><br>"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations." (Chapter 24, Section 10(d)) | Page 6, #9 | Signed by Kyle Quackenbush, Segment President and VP – Liquids (Crude Oil and CO2), Tallgrass. | | |
| **GEOLOGIC NARRATIVE/SITE CHARACTERIZATION INFORMATION** | | | | | |
| *The permit application will likely include a narrative description of the geologic structures, injection and confining zones, and fluid and solid geochemistry to meet the requirements of Chapter 24. The geologic narrative may be supported by maps, cross sections, and tabular data.* | | | | | |
| | **Regional Geologic Structure and Hydrogeologic Properties**<br>*The description of the geologic structure and hydrogeologic properties of the proposed storage site and overlying formations must include the items below:* | | | | |
| | **Maps and Cross Sections of the AoR**<br>*The maps and cross sections may be accompanied by a brief narrative description interpreting the figures and providing an overview of key features important to the project.*<br>• Meets the requirements of Section 13 of this Chapter;<br>• Is based upon modeling; | Appendix B<br>Sections 3.1.1-3.1.2 (pp. 128-132)<br>Section 3.4 (p. 158) | CMG GEM model: "The data sources used to construct the static geocellular model include well logs, 2D seismic data, and elements drawn from available literature."<br><br>Multiple figures have the AOR displayed. | | |

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| | • Uses all available data, including data available from any logging and testing of wells within and adjacent to (within one (1) mile of) the area of review; and<br>• Describes the area of review by township, range, and section to the nearest ten (10) acres, as described under the general land survey system;<br>*(Chapter 24, Section 10(b)(x))* | | Applicant proceeded to use the EERC's risk-based AoR approach but did not offer the results of modelling (i.e. EPA approach) that would have indicated that approach was appropriate.<br><br>**Specific Comment No. 13.** Section 3.1.2 *Supporting Maps* of the permit application states "As discussed in Appendix B, the extent of the pressure front at the critical pressure threshold is smaller than the $CO_2$ plume extent, therefore the AoR is determined by the $CO_2$ plume extent."<br><br>a. Please clarify how you arrived at this conclusion incorporating evaluations of the AoR (using the EPA approach) that indicate a different methodology (i.e. the risk-based approach) is appropriate. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 14 for the other four applications. | |
| | **<u>Demonstration of Site Suitability</u>**<br>*This narrative demonstration may be accompanied by maps, cross sections, tables or relevant geological data, or descriptions of model inputs/results. It must describe:*<br>• The suitability of the injection zone (An injection zone of sufficient areal extent, thickness, porosity, and permeability to receive the total anticipated volume of the carbon dioxide stream (Chapter 24, Section 12 (a)(i)), and<br>• The suitability of the confining zone (Confining zones that are free of transmissive faults or fractures and of sufficient areal extent and integrity to contain the injected carbon dioxide stream and displaced formation fluids and allow injection at proposed maximum pressures and volumes without initiating or propagating fractures in the confining zones or causing non-transmissive faults to become transmissive. *(Chapter 24, Section 12(a)(ii))*<br>*(*) It may also describe additional confining zone(s); a description of additional confining zones is not required of all projects.*<br>• Isopach maps of the proposed injection and confining zones, a structural contour map aligned with the top of the proposed injection zone, and at least two (2) geologic cross-sections of the area of review reasonably perpendicular to each other and showing the geologic formations from the surface to total depth; *(Chapter 24, Section 10(b)(xi)(A))* | Section 1.6 (p. 37)<br>Located throughout Section 2 (pp. 39-127) | Section 1.6 details the criteria used to determine site suitability. Geologic narrative, Cross sections, Structure and Isopach maps for UCZ, Injection Zone and LCZ provided.<br><br>All depths associated with the UCZ, Injection Zone and LCZ are reported in SSTVD with no well elevation reported. Please provide measured depth values for all depths reported in the permit application.<br><br>Upper Confining:<br>Chugwater, MD, Goose<br>Egg, MD Injection Zone:<br>Lyons, MD<br>Lower Confining: Satanka, MD | **Specific Comment No. 22:** Please provide measured depth values for all depths reported in the permit application. This data can be submitted as a table that includes the measured and subsea depths of all formations whose depths were reported only as subsea in the permit application, including the depths and ranges of depths given on pages 67, 70, 94, 96, 103 and 104 of the permit application and | |

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| | | | | pages B-14 and B-17 of Appendix B | |
| X | **Information on Faults and Fractures**<br>*This may be a narrative description of the location, orientation, and properties of known or suspected faults and fractures and a discussion supporting a determination that they would not interfere with containment. It may be accompanied by maps and cross sections and be supported by analyses of core samples, the results of geophysical surveys, pore pressure data, etc.*<br>• Location, orientation, and properties of known or suspected faults and fractures that may transect the confining zones in the area of review and a determination that they will not allow fluid movement;<br>• Information on seismic history that has affected the proposed area of review including knowledge of previous seismic events and history of these events, the presence and depth of seismic sources, and a determination that the seismicity will not allow fluid movement out of the injection zone;<br>*(Chapter 24, Section 10(b)(xi)(B-C))* | Figure 2.17 (p. 74)<br>Section 2.4.3 (pp.118-120) | Figure 2.17 shows the 2D seismic lines used to determine there are no faults in the AoR.<br><br>2.4.3.1 states "The upper confining zone if free of transmissive faults or fractures within the AoR."<br><br>2.4.3.1 also mentions Tallgrass ran SLB oil-based ultrasonic borehole image tool and interpreted open fractures to be drilling induced. Dipole sonic was used to look for open fractures further from the wellbore. There is no discussion of the interpretation of the dipole sonic. | **Specific Comment No. 23:** Please submit a discussion of how the dipole sonic tool was used to determine that open fractures are not transmissive, including a description of the depth of investigation of the dipole sonic tool. | |
| X | **Data on the Injection Zone(s)**<br>*This narrative may describe plans to collect or the results of geologic cores, outcrop data, seismic surveys, well logs, lithologic descriptions, and other field data used to characterize the injection zone(s), including geology/facies changes. The application must address the following types of data on the injection zone(s):*<br>• Data sufficient to demonstrate the effectiveness of the injection and confining zones, including:<br>o Data on the depth, areal extent, thickness, mineralogy, porosity, vertical permeability, and capillary pressure of the injection and confining zones within the area of review; and<br>o A description of geologic changes based on field data that may include geologic cores, outcrop data, seismic surveys, well logs, and names and lithologic descriptions;<br>*(Chapter 24, Section 10(b)(xi)(D))* | Throughout Section 2.4 (pp. 75-124) | Data from the Juniper M-1 strat test:<br>Table 2.22 (p. 99) Lyons: Depth: 9,128'-9,194'; Avg. 67' thick; Sandstone, predominantly quartz with <2% clay and no calcite.<br>Table 2.7 (p. 80) Porosity: 15.7% (core); Perm: 501 mD (core)<br>Section 2.4 focuses on the geological characteristics of the injection zone. Data presented includes core and log data as well as mineralogy. Preliminary geomechanical information indicates a fracture gradient of 0.57 psi/ft and will be updated with future data. Data presented includes core analysis, XRD data, water sampling, cross sections and maps of the Lyons, well logs (Juniper M-1 and others). | | |
| X | **Data on the Confining Zone(s)**<br>*This narrative may describe plans to collect or the results of geologic cores, outcrop data, seismic surveys, well logs, lithologic descriptions, and other field data used to characterize the confining zone(s), including geology/facies changes. The application must address the following types of data on the confining zone(s):*<br>• Data sufficient to demonstrate the effectiveness of the injection and confining zones, including: | Section 2.4.2 including all subsections (pp. 99-118) | Section 2.4.2 including all subsections covers the geology of the UCZ and LCZ. Core, log and geochemical data are provided, as are maps and cross sections. The permeability of the UCZ and LCZ are in the 0.001mD range with 5% avg phi, indicating good sealing rocks are present. The UCZ and LCZ are both predominantly shale and are sufficiently thick (Satanka 189', Chugwater/Goose Egg ~500'). | | |

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| | ○ Data on the depth, areal extent, thickness, mineralogy, porosity, vertical permeability, and capillary pressure of the injection and confining zones within the area of review; and<br>○ A description of geologic changes based on field data that may include geologic cores, outcrop data, seismic surveys, well logs, and names and lithologic descriptions;<br>*(Chapter 24, Section 10(b)(xi)(D))* | | | | |
| | **Geomechanical and Petrophysical Information about the Confining Zone(s)**<br>*A narrative description of the confining zone(s) may describe the testing performed (or planned) and available results in a tabular and/or graphical form; it may include maps and present seismic or other geophysical data, core data, or well logs. The application must address the following about the confining zone(s): (Chapter 24, Section 10(b)(xi)(E))* | Section 2.4.2.1.3 (p. 109)<br>Table 2.25 (p. 110)<br>Section 2.4.2.2.3 (pp. 118-120)<br>Section 2.4.2.2.4 (p. 117)<br>Table 2.28 (p. 117) | Elastic properties available for UCZ and LCZ (some properties pending analysis) are present. | | |
| X | Fractures. | Section 2.4.3.1 (pp. 116-119) | The upper confining zone is free of transmissive faults or fractures within the AoR.<br><br>**Specific Comment No. 3.** In accordance with WWQR, Chapter 24, Section 10(b)(xi)(E), please provide the following geomechanical data:<br><br>a. Stress<br>b. Rock Strength<br>c. In situ fluid pressures<br><br>If this geomechanical data has not yet been collected, please provide a full, stepwise procedure for how this data will be collected for WDEQ review and approval. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 4 for the other four applications. | |
| | Stress. | Table 2.25 (p. 110)<br>Table 2.28 (p. 117) | TBD<br>**Specific Comment No. 3.** | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 4 for the other four applications. | |
| X | Ductility. | Table 2.25 (p. 108)<br>Table 2.28 (p. 115) | Young's modulus for Goose Egg 25.6-55.1.<br>Young's modulus for Satanka 34.6-35.2.<br>**Specific Comment No. 3.** | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment | |

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| | | | | No. 4 for the other four applications. | |
| | Rock strength. | Table 2.25 (p. 110)<br>Table 2.28 (p. 117) | TBD<br>**Specific Comment No. 3.** | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 4 for the other four applications. | |
| | In situ fluid pressures. | | Missing<br>**Specific Comment No. 3.** | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 4 for the other four applications. | |
| X | **Information on Seismic History**<br>*A narrative description of the presence and depth of seismic sources and a determination that seismicity would not interfere with containment that may be accompanied by tables and/or maps of seismic events, sources, and depths. (Chapter 24, Section 10(b)(xi)(C))* | Section 2.4.3.2 (p. 121-124) | "The probabilistic acceleration map, shown in Figure 2.42, illustrates that the EWS Hub is located in one of the lowest-risk areas of Wyoming." | | |
| | **Geologic and Topographic Maps and Cross Sections**<br>*These maps and cross sections of regional geology, hydrogeology, and local geologic structure may be accompanied by a narrative description or interpretations of logs or core data. (Chapter 24, Section 10(b)(xi)(F))* | Throughout Sections 2 & 3 | Myriad maps and cross sections included in Sections 2 & 3. | | |
| | **Hydrologic Information/Maps and Cross Sections of USDWs**<br>*The maps and stratigraphic cross sections of the vertical and lateral limits of all USDWs may be accompanied by a narrative interpretation of the figures. The maps/cross sections must show: (Chapter 24, Section 10(b)(xiv))* | | | | |
| X | Water wells and springs within the AoR. | Figure 3.4 (p. 136) | Embedded map is small scale and difficult to read, however, Tallgrass included a standalone high resolution image in the Figures and Tables folder. | Located in Original Application Material, Figures and Tables folder. | |
| X | Their positions relative to the injection zone(s). | Figure 2.2 (p, 41)<br>Figure 2.7 (p. 47)<br>Figure 2.8 (p. 48) | Shown in stratigraphic column; Figure 2.2<br>Shown on cross section; Figure 2.7, Figure 2.8 | | |
| X | The direction of water movement, where known. | Section 2.2.2 (p. 61)<br>Figure 2.14 (p. 63)<br>Figure 2.20 (p. 78) | Groundwater recharges in the mountains on the western flank of the basin and travels eastward. | | |

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| | **Baseline Geochemical Data**<br>*The narrative description of available geochemical data on fluid- and solid-phase geochemistry of all subsurface formations (including USDWs) in the AoR may describe: results or planned sampling/testing, the parameters analyzed, and any geochemical modeling that was performed, along with data sources, data quality or gaps, and sampling/testing methods. It may be accompanied by tabular or graphical data, statistics, and maps. (Chapter 24, Section 10(b)(xvi))* | Section 4.4.3 #2 (p. 213) | "High Plains has no plans to collect fluid samples from subsequent monitoring wells and will instead collect fluid samples from relevant formations in all injection wells within the EWS Hub."<br><br>Chapter 24 requires water samples from injection zone and lowermost USDW.<br>Only geochemical data for the Lyons is presented.<br><br>**Specific Comment No. 18.** Section 2.3.6 *Fluid Samples* of the permit application states "Based on the narrative of the well operations prior to and during sampling, it is not reasonable or possible to claim that water samples obtained are truly from and representative of the Lyons Formation." Section 2.3.6 (PDF page 69) goes on to state "A review of the daily drilling and completion reports shows there is a possibility that the Lyons Formation water sample collected could be contaminated from brine present in the wellbore at the time of sampling. High Plains will collect additional fluid samples in the Lyons Formation in the Azalea I-1 prior to injection."<br><br>a. Tallgrass will also need to collect water samples from the Sundance Formation, Hygiene Sandstone Member of the Pierre Shale, and the following shallow USDWs:<br><br>i. Quaternary alluvial and terrace deposits<br>ii. "High Plains Regional Aquifer System" or "Tertiary Aquifer System"<br>iii. Ogallala, Arikaree, and White River formations<br>iv. Lance and Fox Hills formations | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 19 for the other four applications. | |
| | **Groundwater Classification**<br>*For the characterization required by W.S. 35-11-313(f)(ii)(B), information necessary for the Division to classify the receiver and any secondarily affected aquifers under Water Quality Rules and Regulations Chapter 8; (Chapter 24, Section 10(b)(xv))* | Section 2.2.1 (pp. 49-58)<br>Section 2.3.6 (pp. 69-71)<br>Appendix C | DEQ has questions on sampling procedure. Permit application also express doubts in water sample quality (Section 2.3.6, pp. 70-71). Will require new sample taken in Spirea I-1 via a sampling methodology approved by WDEQ.<br><br>Lyons TDS ~224,000ppm.<br><br>**Specific Comment No. 19.** Per Specific Comment 19, Tallgrass shall submit their water sampling plan(s) to the WDEQ for | Tallgrass May 9, 2024 Response to WDEQ's | |

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| | | | review and approval prior to collecting any samples, to ensure such samples will be satisfactory to the WDEQ. | Comments. NOTE: This comment is Specific Comment No. 20 for the other four applications. | |
| **WELL CONSTRUCTION** | | | | | |
| X | **CO2 Compatibility**<br>*The compatibility of the carbon dioxide stream with fluids in the injection zone and minerals in both the injection and the confining zones, based on the results of the formation testing program, and with the materials used to construct the well; (Chapter 24, Section 10(b)(xviii))* | Section 2.4.1.8 (pp. 95-99)<br>Section 4.3.2 (p. 193) | Section 2.4.1 Covers formation compatibility.<br>Section 4.3.2 states "To meet the requirements of WYDEQ Chapter 24 §20(b)(iii), High Plains will conduct corrosion monitoring of the well's tubing, casing, and pipeline materials using a corrosion coupon monitoring system." Please provide documentation that all well construction materials meet the various API codes listed in Chapter 24 Section 14.<br><br>**Specific Comment No. 7.** In accordance with WWQR, Chapter 24, Section 10(b)(xxxiii), the well plugging plan requires the type, grade, and quantity of material to be used in well plugging to be submitted. Additionally, please provide information on how these materials meet or exceed the American Petroleum Institute standards per WWQR Chapter 24, Section 14(b)(i). | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 8 for the other four applications. | |
| X | **Formation Testing Program**<br>*Proposed formation testing program to obtain an analysis of the chemical and physical characteristics of the injection zone and confining zone and that meets the requirements of Section 17 of this Chapter; (Chapter 24, Section 10(b)(xix))* | Section 4.3 (pp.188-192)<br>Table 4.21: I-1 logging program (p.207)<br>Table 4.26: M-1 logging program (p. 212) | Please provide summaries of formation testing done in the Juniper and planned for the Spirea I-1 and M-1.<br>Table 4.21 is the Spirea I-1 proposed logging program. Table 4.26 is the Spirea M-1 proposed logging program.<br><br>**Specific Comment No. 4.** In accordance with WWQR, Chapter 24, Section 10(b)(xix), please provide procedures for the formation testing programs to be done in the Spirea I-1 and M-1. | Not Addressed. Additional information is needed in regard to shallow wells, including swab sampling procedures for wells not utilizing MDT. Additionally, please provide a demonstration that using the MDT minifrac tool to | |

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| | | | | determine fracture gradient to establish LSIP is comparable to an injectivity or pump test, such as an SRT. NOTE: This comment is Specific Comment No. 5 for the other four applications. | |
| | **Stimulation Program**<br>*Proposed stimulation program, a description of stimulation fluids to be used, and a determination that stimulation will not allow fluid movement out of the injection zone; (Chapter 24, Section 10(b)(xx))* | Section 5 (pp. 237-240)<br>Appendix J | Section 5 states "A stimulation program will be executed upon WYDEQ approval." Appendix J contains an example of a mud acid workover. It is labelled Proposed Stimulation Plan, but appears incomplete.<br>Proposed plans are acceptable for now, but a detailed workover plan needs to be approved prior to well construction.<br><br>**Specific Comment No. 5.** In accordance with WWQR, Chapter 24, Section 10(b)(xx), a detailed stimulation plan will need to be submitted for WDEQ's review and approval prior to issuance of authorization to inject under a modified permit. If the stimulation is to be done under the Permit to Construct as part of formation testing, this plan needs to be submitted with a response to these comments for WDEQ's review and approval prior to issuance of the Permit to Construct. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 6 for the other four applications. | |
| X | **Schematics**<br>*A wellbore schematic of the subsurface construction details and surface wellhead construction of the injection and monitoring wells; (Chapter 24, Section 10(b)(xxii))* | Figure 4.3 (p. 195)<br>Figure 4.5 (p. 202)<br>Figure 4.6 (p. 209) | Proposed well design for three groundwater monitoring wells.<br>Spirea I-1<br>Spirea M-1 | | |
| X | **Design and Construction**<br>*Injection well design and construction procedures that meet the requirements of Section 14 of Chapter 24, including the information listed in Section 14(c)(ii) of Chapter 24; (Chapter 24, Section 10(b)(xxiv))* | Figure 4.3 (p. 196)<br>Table 4.18 (p.205)<br>Table 4.19 (p.205)<br>Table 4.20 (p. 206) | Tables and wellbore diagrams provide most of the required information. See note regarding API standards in **Well Construction > CO2 Compatibility** in this checklist.<br><br>**Specific Comment No. 16.** Section 4.4.2 *Proposed Monitoring Well Casing and Cementing Programs* of the permit application states "The well will be drilled through the Sundance and will penetrate the top of the Chugwater," whereas Section 4.5.2.1 *Pre-plugging Procedures 2. Determination of bottomhole reservoir pressure* states "The well is not expected to be perforated or open to any formation and the total depth at drilling and completion was to be above the containment layers for the Lyons | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 17 for the other four applications. | |

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| | | | sequestration reservoir."<br><br>a. These statements both refer to the monitoring wells and contradict each other. Please clarify if the Chugwater or Goose Egg will be penetrated by the monitoring well(s).<br>b. Monitor wells cannot penetrate the upper confining zone as drilling operations may compromise the integrity of the confining zone. | Note: Based on the response, monitoring well(s) cannot be drilled until permit modification occurs due to the need to collect data during the injection well drilling. | |
| | **<u>Logging, Sampling and Testing Prior to Injection Well Operations</u>**<br>*All available logging and testing program data on the wells required by Section 17 (Chapter 24, Section 10(b)(xxvii))* | Section 4.3 (pp.188-201) Table 4.21: I-1 logging program (p.207)<br>Table 4.26: M-1 logging program (p. 212) | Please provide summaries of formation testing done in the Juniper M-1 and planned for the Spirea I-1 and M-1.<br>Table 4.21 is the Spirea I-1 proposed logging program. Logging program looks good. Table 4.26 is the Spirea M-1 proposed logging program. Logging program looks good.<br><br>**Specific Comment No. 4.** In accordance with WWQR, Chapter 24, Section 10(b)(xix), please provide procedures for the formation testing programs to be done in the Spirea I-1 and M-1. | Not Addressed. Additional information is needed in regard to shallow wells, including swab sampling procedures for wells not utilizing MDT. Additionally, please provide a demonstration that using the MDT minifrac tool to determine fracture gradient to establish LSIP is comparable to an injectivity or pump test, such as an SRT. NOTE: This comment is Specific Comment No. 5 for the other four applications. | |

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| **PLANNED WELL OPERATIONS** | | | | | |
| X | **Proposed Operations**<br>*Proposed procedure that outlines steps to conduct injection operations; (Chapter 24, Section 10(b)(xxi)* | Section 5.0 (pp. 237-240) | Includes SRT procedures. | | |
| X | **Proposed average and maximum daily rate and volume and/or mass and total anticipated volume and/or mass of the CO2 stream.**<br>*A narrative or tabular description that may be accompanied by calculations. (Chapter 24, Section 10(b)(xvii)(A))* | Table 5.1 (p. 237) | 10.62 million metric tons total over 30 years<br>1,656 metric tons/day average<br>4,101 metric tons/day maximum | | |
| X | **Proposed average and maximum injection pressure.**<br>*A narrative or tabular description that may be accompanied by calculations. (Chapter 24, Section 10(b)(xvii)(B))* | Table 5.1 (pg. 237) | 1,597 psi Maximum Surface Injection Pressure<br>1,420 psi Average Surface Operating Injection Pressure<br>1,520 psi Proposed Tubing-Casing Annulus Pressure | | |
| X | **The source(s) of the CO2.**<br>*A narrative description of the CO2 source. (Chapter 24, Section 10(b)(xvii)(C))* | Section 5.0 (pp. 237-238)<br>Table 5.2 (p. 238) | The $CO_2$ to be injected will be sourced from ethanol plants, ammonia plants, and power plants then transported on the Trailblazer pipeline to the Spirea I-1. | | |
| X | **An analysis of the chemical and physical characteristics of the CO2 stream.**<br>A narrative description that may be accompanied by tables of parameters or analytical reports. *(Chapter 24, Section 10(b)(xvii)(D))* | Table 5.2 (p.238) | >95 mol% CO2 | | |
| X | **Duration**<br>*Anticipated duration of the proposed injection period. (Chapter 24, Section 10(b)(xvii)(E))* | Section 5 (p. 237) | 5-30 years depending on injection rate (up to maximum of 10.62 million metric tons total injection) | | |
| **AREA OF REVIEW (AoR) AND CORRECTIVE ACTION PLAN** | | | | | |
| | *Proposed area of review and corrective action plan that meets the requirements under Section 13 of Chapter 24 (Chapter 24, Section 10(b)(xxv))* | | | | |
| | **The Method for Delineating the AoR.**<br>*A narrative description of the AoR delineation model used, which may include assumptions made, any available outputs/results, and the inputs on which the model is based. It may be accompanied by tables, figures and graphics, or raw data in a tabular format. (Chapter 24, Section 13)* | Section 3.1.1 (p.128) | "The AoR is defined as "the subsurface three-dimensional extent of the carbon dioxide plume, associated pressure front, and displaced fluids, as well as the overlying formations, and surface area above that delineated region" [Ch. 24 §2(c)], the lateral extent of the AoR herein includes any area where the modeled CO2 saturation exceeds 2% at plume stabilization, or where threshold pressure is exceeded in the injection zone at any time during the modeled timeframe."<br><br>The AoR was calculated using the risk-based method, however, the EPA method should have been done first to determine if an alternate method was necessary. Please calculated the AoR using the EPA method and explain why it is or isn't an appropriate method for determining the AoR.<br><br>**Specific Comment No. 13.** Section 3.1.2 *Supporting Maps* of the permit application states "As discussed in Appendix B, the extent of the pressure front at the critical pressure threshold is smaller than the $CO_2$ plume extent, therefore the AoR is | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: | |

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| | | | determined by the $CO_2$ plume extent."<br><br>a. Please clarify how you arrived at this conclusion incorporating evaluations of the AoR (using the EPA approach) that indicate a different methodology (i.e. the risk- based approach) is appropriate | This comment is Specific Comment No. 14 for the other four applications. | |
| X | **AoR Reevaluation Schedule and Criteria, Including:**<br>• *A description of the minimum fixed frequency, not to exceed 5 years, for AoR reevaluations.*<br>• *The monitoring and operational conditions that would warrant a reevaluation of the AoR prior to the next scheduled reevaluation; and*<br>• *How monitoring and operational data will be sued to inform an AoR reevaluation. (Chapter 24, Section 13)* | Section 3.5 (p. 168)<br>Section 3.6 (p. 173) | "High Plains will regularly reevaluate the AoR and corrective action plan, per the requirements of WYDEQ Chapter 24 §13(c), at least every two years during the operational life of the EWS Hub and every five years during the post-injection site care period (until site closure)—or when monitoring and operational conditions warrant a reevaluation prior to the next scheduled reevaluation." | | |
| | **Corrective Action Information**<br>A narrative discussion of how corrective action was/will be conducted. If phased corrective action is planned, the application must describe the following: | Section 3.3 (p. 158)<br>Table 3.10 (p. 168)<br>Section 3.5 (pp. 170-171) | "A total of 654 wells (597 water wells and 57 oil and gas wells) have been identified within the AoR. Of these, only three penetrate the upper confining zone. Two wells are shown in Table 3.10, with Juniper M-1 being discussed separately." This differs from the number of wells within the AoR reported in the Barberry I-1 permit application. Please address this discrepancy.<br><br>Well remediation procedure listed on pp. 170-171.<br><br>**Specific Comment No. 6.** In accordance with WWQR, Chapter 24, Section 13(c)(i-iv), please provide a discussion of how Tallgrass will re-evaluate wells for corrective action within an adjusted AoR.<br><br>a. Section 3.5 *Area or Review and Corrective Action Plan* of the permit application states that there are 654 wells (57 oil wells) within the AoR. The Barberry I-1 permit application (Permit # 2023-039) reports 657 wells (60 oil wells) within the AoR. Please address this discrepancy and adjust Table 3.4 and Table B.6 of Appendix B accordingly.<br><br>**Specific Comment No. 14.** Section 3.6 *Reevaluation of AoR and Corrective Action Plan* of the permit application states "A report will be generated to include the data and results demonstrating that no changes are necessary. If material changes have occurred, then the conceptual model will be updated with the new data and a report will be generated and sent to WYDEQ. This report will | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 7 for the other four applications. | |

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| | | | include comparisons between the previous simulation and the updated version, details of potential corrective action and a current status of the corrective action. The report will be submitted to WDEQ within one year of the reevaluation."<br><br>a. If any change to the AoR has occurred, the conceptual model must be updated and a report generated which must be submitted with the next scheduled semiannual report. If a report that demonstrates no changes are necessary is submitted, it must also be submitted with the next scheduled semiannual report for WDEQ review and approval. Changes to the AoR and corrective action plan will require a permit modification. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 15 for the other four applications. | |
| X | How the phasing will be determined. | | No discussion of phasing corrective action. | Only required if they were planning a phased corrective action. As no phased corrective action planned, no discussion needed. | |
| | How corrective action will be adjusted if there are changes in the AoR. | | No discussion of Corrective Action changes<br>**Specific Comment No. 6.** In accordance with WWQR, Chapter 24, Section 13(c)(i-iv), please provide a discussion of how Tallgrass will re-evaluate wells for corrective action within an adjusted AoR.<br><br>a. Section 3.5 *Area or Review and Corrective Action Plan* of the permit application states that there are 654 wells (57 oil wells) within the AoR. The Barberry I-1 permit application (Permit # 2023-039) reports 657 wells (60 oil wells) within the AoR. Please address this discrepancy and adjust Table 3.4 and Table B.6 of Appendix B accordingly.<br><br>**Specific Comment No. 14.** Section 3.6 *Reevaluation of AoR and Corrective Action Plan* of the permit application states "A report will be generated to include the data and results demonstrating that no changes are necessary. If material changes have occurred, then the conceptual model will be updated with the new data and a report will be generated and sent to WYDEQ. This report will include comparisons between the previous simulation and the updated version, details of potential corrective action and a | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 7 for the other four applications.<br><br>Tallgrass May 9, 2024 Response to | |

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| | | | current status of the corrective action. The report will be submitted to WDEQ within one year of the reevaluation."<br><br>a. If any change to the AoR has occurred, the conceptual model must be updated and a report generated which must be submitted with the next scheduled semiannual report. If a report that demonstrates no changes are necessary is submitted, it must also be submitted with the next scheduled semiannual report for WDEQ review and approval. Changes to the AoR and corrective action plan will require a permit modification. | WDEQ's Comments. NOTE: This comment is Specific Comment No. 15 for the other four applications. | |
| X | How site access for future corrective action will be guaranteed. | Page 5, #7 | Site access is covered on Page 5, #7. | | |
| X | **Tabulation of Wells in the AoR**<br>The AoR and Corrective Action Plan must include a table listing wells within the AoR (within one mile) that penetrate the injection or confining zones or a statement there are no wells that penetrate the confining zone within the AoR. Other penetrations of the confining zone(s), such as underground mines, also must be identified. If a table is submitted, it must include the following information: *(Chapter 24, Section 10(b)(xii-xiii))* | Table 3.4 (pp. 139-142) Table 3.10 (p. 168) Table B.6 (pp. 310-314) Table B.7 (pp. 317-336) | Several tables tabulate wells data for wells within AOR. Table 3.4 is a condensed deep well table and Table B.6 is a more comprehensive table. Table B.7 lists water wells in the AOR, but only has columns for Permit Number, Status, Use, Facility Name and Well Depth. Table 3.10 is a complete table for wells that penetrate the confining zone within the AOR. | Original Application, Table 3.10 | |
| X | Well Type. | Table 3.10 (p. 168) | Present in table. | | |
| X | Description of the well's construction. | Table 3.10 (p. 168) | Present in table. | | |
| X | Date drilled. | Table 3.10 (p. 168) | Present in table. | | |
| X | Location. | Table 3.10 (p. 168) | Present in table. | | |
| X | Depth. | Table 3.10 (p. 168) | Present in table. | | |
| X | Record of plugging and/or completion. | Table 3.10 (p. 168) | WOGCC Completion Reports provided in Appendix A. | | |
| **TESTING AND MONITORING PLAN** | | | | | |
| | **Testing and Monitoring Plan**<br>*Proposed testing and monitoring plan required by Section 20 (Chapter 24, Section 10(b)(xxxii)). The Testing and Monitoring Plan will be a narrative description of planned injection-phase testing activities that is accompanied by maps, tables, illustrations, or step-by-step procedures that describe the following:* | Section 4.3 (pp.188-201) | See below. | | |
| X | **CO2 Stream Analysis**<br>*Narrative description that may describe analytical parameters, sampling methods, sampling locations, and frequencies.* | Section 4.3.1 (pp. 189-19) | "High Plains will collect continuous samples of the $CO_2$ injection stream and perform analysis to meet the requirements of WYDEQ Chapter 24 §20(b)(i), to obtain data representative of the injectate stream's chemical and physical characteristics." "The $CO_2$ stream samples will be continuously collected from the $CO_2$ pipeline using a gas chromatograph on the flowline before the injection flowmeter." | | |

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| X | **Continuous Recording of Operational Parameters**<br>*Narrative description of devices to continuously monitor and record injection pressure, rate, and volume; tubing-casing annulus pressure; and annulus fluid volume added. May be depicted on well schematics.* | | Various mentions of continuous monitoring through fiber optic cables in wellbore, but no specific discussion of continuous monitoring. | **Specific Comment No. 24:** Please provide additional information specific to continuous monitoring. | |
| X | **Corrosion Monitoring**<br>*Narrative description of corrosion monitoring methods that may describe sampling methods/locations or testing frequency.* | Section 4.3.2 Subsection 2 (p. 193) | "The coupons will be removed quarterly and assessed for corrosion using American Society for Testing and Materials (ASTM) standards at a certified laboratory." | | |
| X | **Above Confining Zone Monitoring**<br>*Narrative description of planned water quality monitoring that may describe well locations; analytical methods and parameters; sampling locations and methods, formations/depths, and frequencies. The description may be accompanied by maps, monitoring well schematics, or tables of analytical parameters and methods.* | Table 4.11 (p. 189) | "Monitoring well with fiber optic and gauges behind casing" | | |
| X | **External Mechanical Integrity Testing**<br>*Narrative (sometimes step-by-step) description of mechanical integrity tests (MITs) and their planned frequency. (Chapter 24, Section 10(b)(xxviii))* | Section 4.3.1.1 Subsection 4 (p. 192) | "As required by WYDEQ Chapter 24 §24.19(c) and §24.20(b)(v), a fiber optic (DTS) temperature log will be recorded and archived annually to determine the absence of significant fluid movement, thus ensuring mechanical integrity. Before beginning injection operations, a temperature baseline will be established for future comparisons." | | |
| X | **Pressure Fall-Off Testing**<br>*Narrative (sometimes step-by-step) description of pressure fall-off tests and their planned frequency.* | Section 4.3.1.1 Subsection 2 (p. 191-192) | "High Plains will conduct a baseline pressure falloff test before injection and then every five years." | | |
| X | **Direct CO2 Plume and Pressure Front Tracking**<br>*Narrative description of planned direct methods to track the CO2 plume and pressure front that may include well locations; analytical methods and parameters; sampling locations and formations/depths; and frequencies. The description may be accompanied by maps, monitoring well schematics, or tables of analytical parameters and methods.* | Section 4.3.8 (pg. 196)<br>Table 4.15 (pp. 196-197)<br>Section 4.3.9 (pg. 198) | "Direct and indirect monitoring methods will be used to track the extent of the CO2 plume within the injection formation throughout the injection and post-injection monitoring periods, per the methods described in Table 4.15."<br>"The CO2 plume will be directly monitored by temperature and pressure gauges placed via TEC line as well as a fiber optics system behind the casing in both the injection well and the monitoring well." | | |
| X | **Indirect CO2 Plume and Pressure Front Tracking**<br>*Narrative description of planned indirect methods to track the Co2 plume and pressure front; it may describe: well locations; monitoring equipment; or geophysical survey extent/resolution. The description may be accompanied by maps, monitoring well or equipment schematics, or tables.* | Section 4.3.10 (pg. 198) | "The extent of the $CO_2$ plume will be monitored using time-lapse 2D seismic surveys."<br>"High Plains plans to utilize DTS in the Spirea M-1 annually to monitor all zones above the injection zone. Due to the high resolution nature of this tool, this method of monitoring will inform High Plains of any carbon dioxide or saline fluids migrating out of the injection zone." | | |
| | ***Surface Air Monitoring and/or Soil Gas Monitoring** | Section 4.3.7 (p. 195)<br>Table 4.14 (p.195) | "CO2 in air monitors will also be placed to monitor the air above the water level in each of these monitoring wells." No other air | | |

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| | *This type of monitoring is not required for all projects; if it is included, it would be a narrative description of planned methods detect CO2 in the soil or atmosphere (including monitoring locations, equipment, and frequencies) that may be accompanied by maps or illustrations.* | | monitoring will be done.<br>"High Plains has determined that a soil gas monitoring plan is not necessary to monitor potential Leakage."<br>Soil Gas Monitoring is required.<br>**Specific Comment No. 17.** Section 4.6.3 *Groundwater and Soil Gas Monitoring* of the permit application states "High Plains does not plan to monitor soil gas at this time as monitoring efforts in the first permeable layer above the confining zone and shallow groundwater sampling will identify leaks before a soil gas survey would."<br><br>a. Pursuant to WWQR Chapter 24 Section 20(b)(ix), soil gas monitoring is required. Please provide a soil gas monitoring plan. | Not addressed. Please provide clarification as to when the monitoring well(s) will be drilled. In addition, any updates to construction designs are considered a minor permit modification and therefore, modified plans are required to be submitted to WDEQ for review and approval prior to drilling.<br>Comments. NOTE: This comment is Specific Comment No. 18 for the other four applications. | |
| X | ***Other Monitoring**<br>*Additional monitoring is not required for all projects; if it is included, it would be a narrative description of the types of monitoring (e.g., seismic), including methods, equipment, locations, and frequencies that may be accompanied by maps, illustrations, or tables.* | Table 4.2 (p. 177)<br>Table 4.11 (p. 188) | Seismic monitoring mentioned in Emergency and Remedial Response Plan, Table 4.2. Monitoring program is listed in Table 4.11. | | |
| X | **Quality Assurance and Surveillance Plan**<br>*Narrative description of planned quality assurance procedures for all testing and monitoring activities.* | Table 4.2 (pp. 178-179)<br>Table 4.11 (p. 188) | | | |
| **INJECTION WELL PLUGGING PLAN** | | | | | |
| | *Proposed injection and monitoring wells plugging plan required by Section 23 (Chapter 24, Section 10(b)(xxxiii))* | Section 4.5 (p. 214-219) | "This section provides an overview of plugging operations after injection operations have ceased at Spirea I-1. High Plains intends to properly plug and abandon the injection well under the requirements of WYDEQ Chapter 24 §23." | | |

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| X | **Well Plugging Plan**<br>*The Well Plugging Plan may be a narrative (sometimes step-by-step) description of plugging procedures for the injection well. It may be accompanied by schematics and tables. The plan must include the following information:* | Section 4.5 (p. 214-224)<br>Figure 4.7 (p. 219)<br>Figure 4.8 (p. 224) | Figure 4.7 – P&A Wellbore Diagram for Injector<br>Figure 4.8 – P&A Wellbore Diagram for MW | | |
| X | Tests or measures for determining bottomhole reservoir pressure. | Section 4.5 Pre-plugging procedures #2 (p. 214) | "Bottomhole pressure will be measured with a wireline gauge run through tubing. The well should be shut in for a sufficient time to ensure the reservoir pressures are stabilized." | | |
| X | External mechanical integrity testing methods. | Section 4.5 Pre-plugging procedures #3 (pp. 214-215) | "External mechanical integrity will be demonstrated through approved temperature logging methods. The following procedure is to demonstrate mechanical integrity, release packer, recover tubing, and clean out the wellbore." | | |
| X | The type and number of plugs to be used. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Table 4.27 summarizes plugs, Section 4.5.1 describes the plugs, and Figure 4.7 is the wellbore diagram for the Spirea I-1. | | |
| X | The placement of each plug, including the elevation of the top and bottom of each plug. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Figure 4.7 | | |
| X | The type, grade, and quantity of material to be used in plugging. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Table 4.27 and Figure 4.7. | | |
| X | The method of placement of the plugs. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Narrative in Section 4.5.1 (pp.214-217) | | |
| **POST-INJECTION SITE CARE (PISC) AND SITE CLOSURE PLAN** | | | | | |
| X | **PISC and Site Closure Plan**<br>*Proposed post-injection site care and site closure plan required by Section 24(a)(Chapter 24, Section 10(b)(xxxiv)). The plan will be a narrative discussion, accompanied by maps, cross sections, tables, or model outputs that must include the following information:* | Section 4.6 (pg. 225-236) | | | |
| X | The differential between pre-injection and predicted post-injection pressures in the injection zone(s). | Section 4.6.1 (pg. 225-233) | "The maximum injection pressure buildup is 1,391 psi." | | |
| X | The predicted position of the CO2 plume and associated pressure front at site closure. | Figure 4.14 (p.232) | Map of maximum plume extent. | | |
| X | A description of post-injection monitoring locations, methods, and proposed frequencies. *This may include well locations; analytical methods and parameters; and sampling locations, formations/depths, and frequencies.* | Section 4.6.4 (p.234) | "As indicated in Table 4.4, the $CO_2$ plume and pressure front will be monitored after injection activities cease. Reservoir temperatures and pressures will be measured in injection wells. The extent of the plume will indirectly be measured with time-lapse 2D surveys. Data gathered from these two methods during post-injection will be used to validate the predicted plume model. If data differs from the predicted behavior, the model will | | |

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| | | | be updated." | | |
| X | A proposed schedule for submitting post-injection site care monitoring results. | Section 4.6.5 (pp. 234-235)<br>Table 4.29 (p. 234) | "All data and analysis gathered during PISC monitoring activities will be submitted to WYDEQ and the EPA annually, within 60 days of the anniversary of injection cessation. The reports will contain groundwater data, storage reservoir pressures and temperature, seismic data, and any reservoir simulation results from new data." | | |
| X | The duration of the post-injection site care timeframe. | Section 4.6 (p. 225) | "To be conservative, High Plains plans to conduct post-injection monitoring for 50 years after injection ceases to confirm that the model does not show a risk of migration to the USDW or beyond the Project Site boundary." | | They modeled for 20-30 years but they will continue PISC for 50 years regardless. |
| X | The results of computational modeling of the AoR. | Figure 4.10 (p. 227)<br>Figure 4.11 (p. 228)<br>Figure 4.14 (p. 232) | Discussed in AOR section as well. | | |
| | The predicted rate of CO2 plume migration within the injection zone and the predicted timeframe for the cessation of migration. | Section 4.6.1 (pp. 229)<br>Figures 4.14 (p. 232) | "The rate of CO2 migration within the injection zone is primarily controlled by structural dip, facies, porosity and permeability distribution. A discussion of these geological properties and their adaptation and inclusion in the CO2 plume modeling is included in the application narrative. Figure 4.14 shows the pressures and CO2 plume at end of injection, through stabilization and the end of PISC."<br>No rates reported.<br><br>**Specific Comment No. 8.** In accordance with WWQR, Chapter 24, Section 24(a)(ii)(K), the predicted rate of $CO_2$ plume migration within the injection zone is required. Please update the permit application to include this information. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 9 for the other four applications. | |
| | A description of the site-specific processes that will result in CO2 trapping. | Section 4.6 (pp. 229-230) | "At the end of the modeled timeframe (model year 2105), approximately 8.18 MMT of $CO_2$ is structurally trapped. Residual trapping stores 1.80 MMT. Solubility trapping accounts for approximately 0.61 MMT of $CO_2$ at the end of the model runtime. | | |
| | The predicted rate of CO2 trapping. | Section 4.6 (pp. 229-230) | No rates reported.<br>**Specific Comment No. 9.** In accordance with WWQR, Chapter 24, Section 24(a)(ii)(M), the predicted rate of $CO_2$ trapping is required. Please update the permit application to include this information. | Not addressed. Although graphs are provided, rates are not clearly | |

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| | | | | identified. Please provide a numerical value for the rate at the end of the PISC. NOTE: This comment is Specific Comment No. 10 for the other four applications. | |
| X | The results of laboratory analyses, research studies, and/or field or site-specific studies to verify the above information. | Section 2 and Section 3 | Previously discussed in monitoring section. | | |
| X | A characterization of the confining zone(s), including a demonstration that it is free of faults and fractures and is sufficiently thick, and will impede fluid movement. | Section 2.4.2 including all subsections (pp. 99-118) | Previously discussed. | | |
| X | A description of the well's construction and an assessment of the quality of plugs of all abandoned wells in the AoR. | Section 3.3 (p. 158)<br>Table 3.10 (p. 168)<br>Section 3.5 (pp. 168-173) | Previously discussed. | | |
| X | The distance between the injection zone and the nearest USDWs. | Figure 2.2 (p. 41)<br>Figure 2.7 (p. 47)<br>Figure 2.8 (p. 48) | Previously discussed. | | |
| **EMERGENCY AND REMEDIAL RESPONSE PLAN** | | | | | |
| X | Proposed emergency and remedial response plan required by Section 25 (Chapter 24, Section 10(b)(xxxv)) | Section 4.1 (pp. 175-184) | | | |
| **FINANCIAL ASSURANCE** | | | | | |
| | A demonstration, satisfactory to the Administrator, that the applicant has met the financial responsibility requirements of Section 26; (Chapter 24, Section 10(b)(xxix)) | Section 4.2 (pp. 184-188) | Monitoring and testing financial assurance is missing. **Specific Comment No. 10.** In accordance with WWQR, Chapter 24, Section 26(a)(ii), financial assurance for each phase of the project is required including monitoring and testing; financial assurance for each phase is required to be reported separately from other financial assurance estimates. | Not addressed. Please explain why the ERR Monte Carlo simulation for the Spirea returned different results than the other four wells which had results that appeared to be identical to each other. NOTE: This comment is Specific Comment No. 11 for the other four applications. | |

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| X | A written financial assurance cost estimate required by Section 26(b); (Chapter 24, Section 10(b)(xxx)) | Appendix G | Written financial assurance cost estimate provided in Appendix G. | | |
| | A public liability insurance certificate that, in addition to meeting the requirements of W.S. § 35-11-313(f)(ii)(O), demonstrates that the public liability insurance policy meets the requirements of Section 26(l)(i)(B) of this Chapter; identifies each facility by name, address, and EPA Identification Number; and identifies the amounts and types of coverage for each facility; (Chapter 24, Section 10(b)(xxxi)) | Appendix G | Certificate is blank and needs to be completed prior to permit to construct.<br><br>**Specific Comment No. 11.** In accordance with WWQR, Chapter 24, Section 10(b)(xxxi), a public liability insurance certificate that, in addition to meeting the requirements of W.S. § 35-11-313(f)(ii)(O), demonstrates that the public liability insurance policy meets the requirements of Section 26(l)(i)(B) of this Chapter; identifies each facility by name, address, and EPA Identification Number; and identifies the amounts and types of coverage for each facility is required prior issuance of a Permit to Construct. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 12 for the other four applications. | |
| **GENERAL COMMENTS** | | | | | |
| | The basis for the following comments is identified below as part of the Application Completeness/Preliminary Technical Adequacy Review. A checklist for the application is attached for further reference. | | **General Comment No. 1.** The basis for the following comments is identified below as part of the Application Completeness/Preliminary Technical Adequacy Review. A checklist for the application is attached for further reference. | NA | |
| | Applicants have a maximum of six (6) months to address WDEQ's comments. If the requested information is not addressed within the six (6) month period, the permit will be denied and the incomplete application shall be returned. | | **General Comment No. 2.** Applicants have a maximum of six (6) months to address WDEQ's comments. If the requested information is not addressed within the six (6) month period, the permit will be denied and the incomplete application shall be returned. | Response to DEQ's comments received May 9, 2024. | |
| | Resubmittal of information for a deficient application will start the sixty (60) day review period again. | | **General Comment No. 3.** Resubmittal of information for a deficient application will start the sixty (60) day review period again. | Response from DEQ to be received no later than July 9, 2024. | |
| | Please ensure consistent units are used throughout the application. For example, SSTVD is reported in some situations while MD is used in others. While SSTVD is acceptable, please also report the corresponding MD. | | **General Comment No. 4.** Please ensure consistent units are used throughout the application. For example, SSTVD is reported in some situations while MD is used in others. While SSTVD is acceptable, please also report the corresponding MD. | Not addressed. See **Specific Comment No. 22** above. | |
| | Please ensure to use a consistent operator name throughout the application. | | **General Comment No. 5.** Please ensure to use a consistent operator name throughout the application. | Not addressed. Please provide an updated Form 1 for each well as follows:<br>• Spirea: Correct operator name | |

| √ | REQUIRED ITEM | LOCATION IN APPLICATION | COMMENT | COMMENT ADDRESSED? | FINAL REVIEW |
|---|---|---|---|---|---|
| | | | | from Trailblazer High Plains Carbon Storage LLC. to Tallgrass High Plains Carbon Storage LLC and correct the conflicting Section, Township and Range information provided in Parts 1 and 2 | |
| **ADDITIONAL COMMENTS** | | | | | |
| | Section 2.4.1.5 of the permit application states "Note oil saturation > 0 is indicative of oil-based mud invasion." Provide evidence as to how oil saturation in the core taken in the Juniper M-1 can be as high as 46% due to drilling with oil-based mud. | | **Specific Comment No. 12.** Section 2.4.1.5 of the permit application states "Note oil saturation > 0 is indicative of oil-based mud invasion." Provide evidence as to how oil saturation in the core taken in the Juniper M-1 can be as high as 46% due to drilling with oil-based mud. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 13 for the other four applications. | |
| | Table 4.3 *Actions necessary to determine cause of events and appropriate emergency response* of the permit application states "If a seismic event occurs within the AoR of the injection well, of a magnitude greater than 3.0, review the pressure and volume injection history to determine if there is a correlation with the injection activities. Confirm that the well has maintained mechanical integrity and whether a loss of $CO_2$ containment has occurred."<br><br>The WDEQ requires quarterly reporting of all seismic events greater than 1.0. At this time, the WDEQ cannot support a minimum magnitude reporting threshold of 3.0. Final minimum magnitude reporting threshold numbers cannot be established until further data is collected from the well area. | | **Specific Comment No. 15.** Table 4.3 *Actions necessary to determine cause of events and appropriate emergency response* of the permit application states "If a seismic event occurs within the AoR of the injection well, of a magnitude greater than 3.0, review the pressure and volume injection history to determine if there is a correlation with the injection activities. Confirm that the well has maintained mechanical integrity and whether a loss of $CO_2$ containment has occurred."<br><br>a. The WDEQ requires quarterly reporting of all seismic events greater than 1.0. At this time, the WDEQ cannot support a minimum magnitude reporting threshold of 3.0. Final minimum magnitude reporting threshold numbers cannot be established until further data is collected from the well area | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 16 for the other four applications. | |
| | Tallgrass shall submit final plans for water sampling, monitoring, completions, injection and monitor well plugging, internal and external mechanical integrity testing, and any other well operation | | **Specific Comment No. 20.** Tallgrass shall submit final plans for water sampling, monitoring, completions, injection and monitor well plugging, internal and external mechanical integrity testing, | Tallgrass May 9, 2024 Response to WDEQ's | |

| √ | REQUIRED ITEM | LOCATION IN APPLICATION | COMMENT | COMMENT ADDRESSED? | FINAL REVIEW |
|---|---|---|---|---|---|
| | procedures to the WDEQ for review and approval prior to performing any of these activities. | | and any other well operation procedures to the WDEQ for review and approval prior to performing any of these activities. | Comments. NOTE: This comment is Specific Comment No. 21 for the other four applications. | |
| **May 9, 2024 Tallgrass Submittal – additional Barberry I-1, Azalea I-1, Old Barberry I-1, Spirea I-1, and Cypress I-1 Permit Updates and Proposed Changes** | | | | | |
| | Page 50 of 61: Step Rate Test | Tallgrass May 9, 2024 Response to WDEQ's Comments. | | **Specific Comment No. 4** not addressed. See WDEQ's follow-up questions/comments to Tallgrass Response for missing information to WDEQ Specific Comment No. 4 NOTE: This comment is Specific Comment No. 5 for the other four applications. | |
| | Page 50 of 61: Injection Well 130' Rathole Justification | Tallgrass May 9, 2024 Response to WDEQ's Comments. | | | |
| | Page 55 of 61: "This supports the conclusion that the Amazone is not considered a USDW." | Tallgrass May 9, 2024 Response to WDEQ's Comments. | Although the "Application for Class II wells-Samson Energy 2020" notes that the TDS of the Amazon is greater than 10,000 ppm, there are several locations that are below 10,000 ppm. The conclusions drawn in that report that "drilling mud" caused the decrease in concentrations, information on the drilling mud would need to be provided to confirm this claim.<br><br>Note: This does not need to be answered prior to Permit to Construct. | **Specific Comment No. 25:** TDS concentrations can be determined through sample analysis or calculation from conductivity information available. Please provide additional information to support that the Amazon is not a USDW. | |

| √ | REQUIRED ITEM | LOCATION IN APPLICATION | COMMENT | COMMENT ADDRESSED? | FINAL REVIEW |
|---|---|---|---|---|---|
| | Specific Comment No. 21 | | This checklist will not have a Specific Comment No. 21 in order to align other Specific Comments 22, 23, 24, and 25 to the other four permit applications and avoid confusion in addressing comments. | No Specific Comment No. 21. | |

5 July 2024

**VIA E-MAIL AND WDEQ PORTAL**

Wyoming Department of Environmental Quality
c/o Lily Barkau
200 West 17th Street
Cheyenne, Wyoming 82002
Lily.Barkau@wyo.gov
cc: Tyler.Harris@wyo.gov

*Submitted electronically:* WDEQ Water Quality Division Document Uploads (smartsheet.com)
*Permits: 2023-039, 2023-264, 2023-041, 2023-263, 2023-040*

Dear Ms. Barkau:

Tallgrass High Plains Carbon Storage, LLC. has submitted the Response to Comments Issued on June 28th, 2024. The files are located on a secure SharePoint: Comment Responses Issued June 28. High Plains looks forward to your correspondence on these permits.

Kind Regards,

Katy Larson

Katy Larson
Geoscience Compliance Manager
Tallgrass Energy Partners, LP

**Underground Injection Control Carbon Sequestration**

**Class VI Permit Application**

**Eastern Wyoming Sequestration Hub**

**Permit Numbers 2023-039, 2023-264, 2023-041, 2023-263, 2023-040**

**Facility ID Numbers WYS-021-00153, WYS-021-00159, WYS-021-00155, WYS-021-00158, WYS-021-00154**

**Response to WDEQ Comments**

**July 5, 2024**

Prepared by:

Kyle Quackenbush (Executive Contact)
Katy Larson (Compliance Manager)
Tallgrass High Plains Carbon Storage, LLC
4200 West 115th Street
Leawood, KS 66211

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# RESPONSE TO COMMENTS

## WDEQ Original General Comment No. 4

### *WDEQ Original General Comment No. 4:*

*Please ensure consistent units are used throughout the application. For example, SSTVD is reported in some situations while MD is used in others. While SSTVD is acceptable, please also report the corresponding MD.*

*(June 27, 2024): Not addressed. Please see Specific Comment No. 22 below for further information.*

### *Original General Comment No. 4 Response:*

Please refer to "WDEQ June 27, 2024 Specific Comment No. 22" of this text.

## WDEQ Original General Comment No. 5

### *WDEQ Original General Comment No. 5:*

*Please ensure to use a consistent operator name throughout the application.*

*(June 27, 2024): Please provide an updated Form 1 as follows:*

- ***Barberry**: Correct operator name from "Trailblazer High Plains Carbon Storage LLC." to "Tallgrass High Plains Carbon Storage LLC."*
- ***Spirea**: Correct operator name from "Trailblazer High Plains Carbon Storage LLC." to "Tallgrass High Plains Carbon Storage LLC" and correct the conflicting Section, Township and Range information provided in Parts 1 and 2.*
- ***Azalea**: Correct operator name from "Trailblazer High Plains Carbon Storage LLC." to "Tallgrass High Plains Carbon Storage LLC"*
- ***Cypress and Old Barberry**: No further action required at this time.*

### *Original General Comment No. 5 Response:*

Form 1s for the three applications have been corrected to display the accurate operator name. The updated forms are provided in the Attachments folder in a sub-folder called "Form 1". The file names are as follows:

- **Barberry**: Form 1_Barberry I-1 Class VI_Application.pdf
- **Spirea**: Form 1_Spirea I-1 Class VI_Application.pdf
- **Azalea**: Form 1_Azalea I-1 Class VI_Application.pdf

## WDEQ Original Specific Comment No. 5

### *WDEQ Original Specific Comment No. 5:*

*In accordance with WWQR, Chapter 24, Section 10(b)(xix), please provide procedures for the formation testing programs to be done: in all I-1 and M-1 wells.*

*(June 27, 2024): Additional information is needed in regard to shallow wells, including swab sampling procedures for wells not utilizing MDT. Additionally, please provide a demonstration that using the MDT minifrac tool to determine fracture gradient to establish LSIP is comparable to an injectivity or pump test, such as an SRT.*

### *Original Specific Comment No. 5 Response:*

Additional Information on How Shallow Wells Will Be Sampled:

The shallow groundwater monitoring wells that will be installed near Juniper I-1 will have dedicated pumps (e.g., Bennett Pumps, www.bennettsamplepump.com) installed. The dedicated pumps will be hung so that the intake is located near the mid-point of the screen interval. The pumps are operated using compressed gas (e.g., nitrogen). The compressed gas used to operate the pumps is exhausted above ground via an exhaust line. Flow from the dedicated pumps is adjustable using a pump controller. The wells will be purged using low-flow methods. The anticipated flow rate during purging and sampling is 0.5 liters per minute or less. Field parameters will be monitored using a flow cell and a Horiba U-52 multiparameter meter capable of measuring pH, specific conductivity, temperature, oxidation-reduction potential (ORP), turbidity, and dissolved oxygen (DO). The wells will be purged until field parameters stabilize. Field parameters will be collected on a periodic basis (e.g., every two minutes) until the stabilization criteria are met for three consecutive readings. The stabilization criteria will include: pH change <= 0.1 SU, specific conductivity change <= 10%, and temperature change <= 1.0 °C. Well drawdown will be monitored during well purging operations. Depth-to-water readings will be recorded concurrently with field parameter measurements. Groundwater samples will be collected following field parameter stabilization.

Demonstration that using the MDT minifrac tool to determine fracture gradient to establish LSIP is comparable to an injectivity or pump test, such as an SRT:

For a thick, basically uniform sandstone formation, like the Lyons, frac pressure is essentially the same whether measured in a short interval within the zone (MDT SRT) or measuring it by a larger frac created with a larger fluid volume to cover most of the zone (pump truck SRT). The result is the same—fracture pressure.

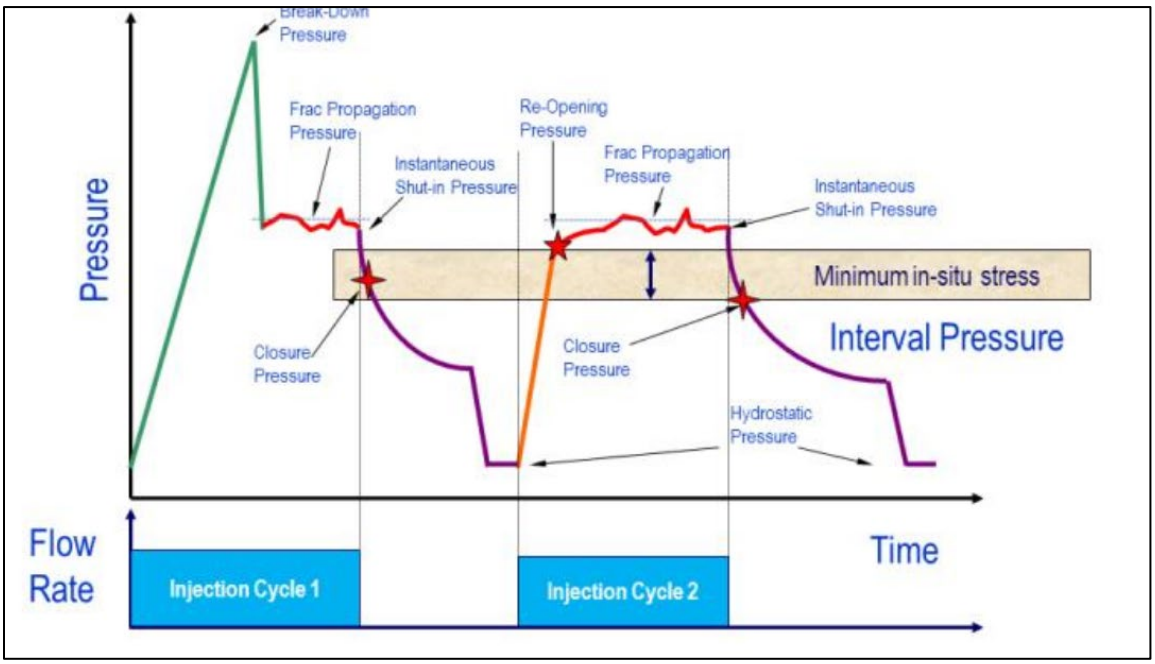
Chapter 24 rules state that the operator must determine the fracture pressure in both the injection and confining zones, for the purpose of establishing LSIP (Limiting Surface Injection Pressure) at 90% of the injection zone fracture pressure. The expectation is that the confining layer, having no measurable permeability, will have a higher frac pressure than the injection layer.

Pump Truck SRT's in zones risks well integrity of the injector well that is cased and cemented at the time of the SRT operation. MDT mini-fracs are small and short in vertical extent and are not

likely to cause any well integrity problems. If an MDT mini-frac fails to obtain reliable frac pressure data, then a limited volume pump truck SRT could be considered for the injection layer, using proper frac fluid, to create the fracture without excessive risk of fracture growth up into the cap rock or confining zone above.

**MDT In-Situ & Limited SRT Injection Test**

The mini-frac (small volume microscopic fracture) with the MDT tool (modular tool run via wireline during the drilling phase) and a larger volume step-rate test (SRT) with a pump truck (performed post-drilling) both entail injecting fluid into the formation until it reaches fracture breakdown pressure. The difference between the two methods is the volume of fluid pumped and the extent of the fracture created. Please see additional information on MDT in-situ testing further in this response.




Upper Confining Zone: The Goose Egg Formation upper confining zone has near-zero permeability. Any attempt to determine the fracture pressure of this layer should be done on a small scale to avoid damaging the zone and compromising its sealing and confining abilities. The MDT mini-frac is the only practical way to test this interval without damaging the integrity of the formation in the injector well. The plan is to prove the integrity of the zone up to a pre-set value, below the fracture pressure—we will not be breaking down/fracturing a confining zone.

Injection Zone: Determining the fracture pressure of the Lyons Formation will be done with both methods, the MDT mini-frac, as well as a larger volume and interval fracture breakdown done via a pump-truck driven step-rate test (SRT). This pump-in SRT will be conducted across a relatively limited interval, 5–10 ft, near the top of the approximately 60 ft thick Lyons Formation. The extent of the induced fracturing will be limited to a volume sufficient to adequately measure fracture pressure without risking the mechanical integrity of the overlying confining layer and cement

sheath of the injection well. The planned SRT would require a few barrels of fracture fluid and be pumped at a modest rate (notionally less than 10 barrels per minute).

The Lyons Formation is very permeable; thus, it will accommodate high rates and volumes of fluid before reaching fracture pressure, making it difficult to correctly determine fracture pressure. To properly create the fracture breakdown and accurately measure the closure stress and true fracture pressure, may require using a heavy gelled and potentially cross-linked viscous fracturing fluid. This extent is much larger than the MDT mini-frac but limited compared to the full thickness of the Lyons Formation.

Conducting a large, full-interval (±60 ft) SRT could cause significant formation damage and impair the well's capacity for $CO_2$ injection. Such a large SRT could also risk the injection well's integrity due to exceeding fracture pressure over such a large interval. Once the SRT testing is completed, the injection well will be properly perforated over the entire Lyons zone and completed to minimize formation damage and ensure effective $CO_2$ injection.

In summary, High Plains will utilize both the MDT Mini-Frac and a limited-scope injection test to determine the true and accurate fracture gradient.

## WDEQ Original Specific Comment No. 10

### *WDEQ Original Specific Comment No. 10:*

*In accordance with WWQR, Chapter 24, Section 24(a)(ii)(M), the predicted rate of CO2 trapping is required.*

*(June 27, 2024): Although graphs are provided, rates are not clearly identified. Please provide a numerical value for the rate at the end of the PISC.*

### *Original Specific Comment No. 10 Response:*

The modeled trapping rates at the end of post-injection site care/site-closure (2105) are provided in the **Table RTC2-1**.

Table RTC2-1—Table listing trapping rates by mechanism at site closure.

| | Trapping Mechanisms (tonnes/year) | | |
|---|---|---|---|
| **Well** | **Dissolved** | **Trapped** | **Critical Gas** |
| **Azalea** | 7,912 | 15,827 | 115,028 |
| **Barberry** | 6,770 | 13,669 | 98,426 |
| **Cypress** | 5,116 | 10,328 | 74,369 |
| **Old Barberry** | 353 | 712 | 5,125 |
| **Spirea** | 1,643 | 3,318 | 23,888 |

## WDEQ Original Specific Comment No. 11

### *WDEQ Original Specific Comment No. 11:*

*In accordance with WWQR, Chapter 24, Section 26(a)(ii), financial assurance for each phase of the project is required including monitoring and testing; financial assurance for each phase is required to be reported separately from other financial assurance estimates.*

- ***Barberry**: In Table 12, the subtotal for monitoring is incorrect. Please revise the monitoring subtotal to reflect the correct calculation.*
- ***Spirea**: Please explain why the ERR Monte Carlo simulation for the Spirea returned different results than the other four wells which had results that appeared to be identical to each other. (Note, this was WDEQ Original Specific Comment No. 10 in the Spirea comment letter).*
- ***Old Barberry**: Please submit a Financial Assurance Demonstration Plan for the Old Barberry permit application.*
- ***Azalea and Cypress**: No further action required at this time.*

### *Original Specific Comment No. 11 Response:*

**Spirea:**

The Spirea plume (AoR) remains distinct and does not merge with the plumes generated by the other five wells (the "five well plume"). Consequently, the Spirea ERR model was handled independently.

The ERR Monte Carlo simulation is specific to each plume/AoR. Specifically, the simulation is tailored to the individual characteristics of each plume/AoR and the pathways by which risk-based event activities are likely to present therein.

For these reasons, it is not unexpected that the Monte Carlo simulation would yield different results for wells in different plumes/AoRs. For example, the Spirea AoR includes the population center of Carpenter, which can result in greater emergency and remedial response costs compared to the five well plume, as the latter does not contain a similar population center.

The difference in risk pathways between the Spirea and the five well plume AoRs is such that High Plains would expect the ERR Monte Carlo simulation to return different results for Spirea than for the five well plume area.

**Old Barberry:**

The Financial Assurance and supporting appendices are submitted in the "Financial Assurance Old Barberry" subfolder of the "Attachments" folder.

**Barberry:**

Table 12—Financial assurance cost estimations for PISC and site closure.

| Post-Injection Site-Care (50 years) and Facility Closure | |
|---|---|
| **Monitoring** | |
| 2D Time-lapse Seismic Survey (1/6$^{th}$ of $2,808,000) | $468,000 |
| Soil Gas Monitoring | $128,750 |
| Ground Water Monitoring | $2,400,000 |
| Air Monitoring | $2,057,600 |
| Testing and Monitoring Logs | $4,212,000 |
| **Subtotal** | **$9,266,350** |
| **Operations and Maintenance of Monitoring Wells** | |
| **Subtotal** | **$2,160,000** |
| **Barberry M-1 Plugging** | |
| **Subtotal** | **$522,000** |
| **Surface Facilities Closure** | |
| **Subtotal** | **$600,000** |
| **PISC and Facility Closure Total** | |
| **Total** | **$12,548,350** |

## WDEQ Original Specific Comment No. 17

### *WDEQ Original Specific Comment No. 17:*

*Section 4.4.2 Proposed Monitoring Well Casing and Cementing Programs of the permit application states "The well will be drilled through the Sundance and will penetrate the top of the Chugwater," whereas Section 4.5.2.1 Pre-plugging Procedures 2. Determination of bottomhole reservoir pressure states "The well is not expected to be perforated or open to any formation and the total depth at drilling and completion was to be above the containment layers for the Lyons sequestration reservoir."*

*(June 27, 2024): Please provide clarification as to when the monitoring well(s) will be drilled. In addition, any updates to construction designs are considered a minor permit modification and therefore, modified plans are required to be submitted to WDEQ for review and approval prior to drilling.*

### *Original Specific Comment No. 17 Response:*

The planned above injection zone monitoring wells (M-1) will be drilled following the drilling of the injector wells but before receiving Authorization to Inject. Proposed groundwater monitoring wells will also be drilled prior to commencing injection. Any updates to construction designs will be submitted to WDDEQ for review and approval prior to drilling.

## WDEQ June 27, 2024 Specific Comment No. 22

### *WDEQ June 27, 2024 Specific Comment No. 22:*

*Please provide measured depth values for all depths reported in the permit application. This data can be submitted as a table that includes the measured and subsea depths of all formations whose depths were reported only as subsea in the permit application, including the depths and ranges of depths given on*

- ***Barberry:*** *pages 66, 69, 93, 95, and 102-103 of the permit application and pages B-14 and B-17 of Appendix B.*
- ***Spirea:*** *pages 67, 70, 94, 96, 103 and 104 of the permit application and pages B-14 and B-17 of Appendix B.*
- ***Cypress****: pages 67, 70, 94, 96, 103, and 104 of the permit application and page B-14 and B-17 of Appendix B.*
- ***Old Barberry****: pages 67, 70, 94, 96, 103, and 104 of the permit application and pages B-14 and B-17 of Appendix B.*
- ***Azalea****: pages 67, 70, 94, 96, 103 and 104 of the permit application and pages B-14 and B-17 of Appendix B.*

### *WDEQ June 27, 2024 Specific Comment No. 22 Response:*

Table 2.6 listing the subsea depths of key formations on page 66 of the Barberry application and page 67 of the Spirea, Cypress, Old Barberry, and Azalea applications has the average depth of the formations within the project area. These depths are not well-specific so a measured depth (MD) is inappropriate. A true vertical depth (TVD) below ground level is appropriate and would be a close approximation of the average MD to each formation for a vertically drilled well. Table RTC2-2 is a reproduced version of Table 2.6 and also includes the average TVD of each formation, assuming an average surface elevation in the storage area of 5,347 ft above sea level.

Table RTC2-2—Reproduce Table 2.6 from the permit applications with average true vertical depth (TVD) to each formation added.

| Formation | Purpose | Average Thickness at Project Site (ft) | Average Depth at Project Site (SSTVD, ft) | Average Depth at Project Site (TVD, ft)* | Lithology |
|---|---|---|---|---|---|
| Chugwater | Upper Confinement | 249 | -3,280 | 8,627 | Interbedded silt and red shale |
| Goose Egg | Upper Confinement | 248 | -3,529 | 8,876 | Interbedded anhydrite and shale |
| Lyons | Injection Interval | 67 | -3,777 | 9,124 | Aeolian sandstone |
| Satanka | Lower Confinement | 189 | -3,843 | 9,190 | Interbedded silt and red shale |

*Assumes an average ground surface elevation of 5,347 ft.

A table listing the anticipated depths of the formations at the locations of each of the proposed wells in provided in Table RTC2-3 below:

Table RTC2-3—The sub-sea true vertical depths (SSTVD) and measured depths (MD) the listed formations are anticipated to be encountered in each of the proposed injection wells.

| | Azalea I-1[1] | | Barberry I-1[2] | | Cypress I-1[1] | | Old Barberry I-1[1] | | Spirea I-1[1] | |
|---|---|---|---|---|---|---|---|---|---|---|
| Formation | SSTVD (ft) | MD (ft) | SSTVD (ft) | MD (ft) | SSTVD (ft) | MD (ft) | SSTVD (ft) | MD (ft) | SSTVD (ft) | MD (ft) |
| T. Chugwater | -3,358 | 8,819 | -3,166 | 8,528 | -3,163 | 8,461 | -2,972 | 8,128 | -3,464 | 8,899 |
| T. Goose Egg | -3,586 | 9,047 | -3,395 | 8,757 | -3,384 | 8,682 | -3,174 | 8,330 | -3,743 | 9,178 |
| T. Lyons | -3,888 | 9,349 | -3,702 | 9,064 | -3,653 | 8,951 | -3,460 | 8,616 | -4,012 | 9,447 |
| T. Satanka | -3,950 | 9,411 | -3,758 | 9,120 | -3,712 | 9,010 | -3,533 | 8,689 | -4,077 | 9,512 |

1. Additional information for depths listed on pages 70, 94, 96, 103, and 104 of the permit application and page B-14 and B-17 of Appendix B.
2. Additional information for depths listed on pages 69, 93, 95, and 102-103 of the permit application and pages B-14 and B-17 of Appendix B.

## WDEQ June 27, 2024 Specific Comment No. 23

### *WDEQ June 27, 2024 Specific Comment No. 23:*

*Please submit a discussion of how the dipole sonic tool was used to determine that open fractures are not transmissive, including a description of the depth of investigation of the dipole sonic tool.*

### *WDEQ June 27, 2024 Specific Comment No. 23 Response:*

The dipole sonic was analyzed for the Stoneley wave response inside the Juniper M-1 wellbore to interpret the relative "openness" of natural fracturing. Attenuation of the Stoneley wave inside the wellbore, as detected by the dipole sonic, can be suggestive of open fracturing as the Stoneley wave pulses into open fractures in the wellbore wall. In the Juniper M-1 a limited attenuation of the Stonely wave was observed across the storage complex. This supports an interpretation of limited fracture openness.

In the analysis conducted on the Juniper M-1 well, the dipole sonic tool was employed to evaluate the relative openness and transmissivity of natural fractures across the upper confining interval. The primary focus was on the attenuation response of the Stoneley wave inside the wellbore. A more detailed explanation is provided:

**Stoneley Wave Attenuation Analysis:**

- Attenuation of the Stoneley wave, as detected by the dipole sonic tool, is used to infer the presence and openness of fractures. Significant attenuation of the Stoneley wave occurs when wave pulses into voids created by open fractures, with greater attenuation suggesting higher fracture intensity, larger apertures, and greater open fracture volumes behind the wellbore wall. This attenuation can also be caused by borehole rugosity (bad hole conditions).

**Juniper M-1 Interpretation:**

- In the Juniper M-1 well, the Stoneley wave response was analyzed using the dipole sonic tool. The results indicated some attenuation in areas of rougher borehole sections, which is typical and

expected. However, there was very limited attenuation observed in intervals identified by the borehole image log as containing fractures.

- The limited Stoneley wave attenuation across intervals identified as containing fractures in the image log suggests that these fractures are not significantly open or transmissive. This conclusion is independently supported by the borehole image interpretation, which also indicated that the fractures within the storage complex section were predominantly limited in openness.

**Depth of Investigation:**

- The depth of investigation for the dipole sonic tool in detecting anisotropy and fracture-related features is approximately 2–3 ft. This range allows for the effective detection and analysis of the relative openness and transmissivity of fractures near the wellbore.

## WDEQ June 27, 2024 Specific Comment No. 24

### *WDEQ June 27, 2024 Specific Comment No. 24:*

*Please include in the monitoring plan that total cumulative volume injected will be reported.*

### *WDEQ June 27, 2024 Specific Comment No. 24 Response:*

Total cumulative volume will be reported for all injector wells including Azalea I-1, Barberry I-1, Old Barberry I-1, Spirea I-1, and Cypress I-1.

## WDEQ June 27, 2024 Specific Comment No. 25

### *WDEQ June 27, 2024 Specific Comment No. 25:*

*TDS concentrations can be determined through sample analysis or calculation from conductivity information available. Please provide additional information to support that the Amazon is not a USDW.*

### *WDEQ June 27, 2024 Specific Comment No. 25 Response:*

Tallgrass is preparing additional information to support that the Amazon is not a USDW.

## WDEQ June 27, 2024 Specific Comment No. 26 (Cypress and Old Barberry only)

### *WDEQ June 27, 2024 Specific Comment 26 (Cypress and Old Barberry only):*

*Cypress M-2 was drilled as a strat test and was not completed as a monitoring well. As Cypress M-2 is located in the AoR, a review for whether corrective action is necessary is required. Please provide all information regarding drilling procedures, any construction activities completed on the monitoring well, plugging and abandonment procedures and final report.*

### *WDEQ June 27, 2024 Specific Comment No. 26 (Cypress and Old Barberry only) Response:*

**Summary of Cypress M-2 Plugging and Abandonment (P&A) Operation:**

**Drilling Summary:**

The daily drilling report is provided in: **Tallgrass Cypress M-2 Daily Drilling Report (dated 1-24 & 1-25).pdf**

**Plugging and Abandonment Summary:**

The well was successfully and permanently plugged and abandoned on May 25, 2024. The P&A operation included a comprehensive design incorporating eight cement plugs, ensuring compliance with standards set by Wyoming Department of Environmental Quality, Wyoming Oil and Gas Conservation Commission, the Environmental Protection Agency (EPA), and the American Petroleum Institute (API).

Notably, Plug 8 was placed across the Lyons Formation, the intended storage zone, using an acid-resistant cement blend (SLB's EverCrete). This plug was tagged and confirmed with a weight on bit of 10,000 lbs after achieving a compressive strength of 500 psi approximately 15 hours post-placement.

**Supporting Documents:**

For a thorough review, we have attached the following documents, which illustrate the robust P&A design and the successful execution of the Cypress M-2 P&A operation:

- Cypress M-2 WBD - PLUG AND ABANDONMENT - 1-22-24.pdf
- Cypress M-2 Well Construction Procedures (Plug and Abandon) v4.pdf
- "SLB Procedure, Treatment and Lab Reports -All Plugs": A folder containing all Schlumberger plug procedures, treatment, and lab reports.

These documents provide detailed insights into the procedures and methodologies employed during the drilling and P&A phases, confirming that all regulatory requirements were meticulously followed.

## WDEQ June 27, 2024 Specific Comment No. 27 (Cypress only)

### *WDEQ June 27, 2024 Specific Comment 27 (Cypress only):*

*Permit Application, Page 4, 2. Site and Facility Description and the updated Form 1 submitted with the Response to Comments dated May 10, 2024 both note that the proposed project will be located in the "Southwestern corner of Wyoming." Please revise all references to southwestern corner to southeastern corner.*

### *WDEQ June 27, 2024 Specific Comment No. 27 (Cypress only) Response:*

Form 1 for Cypress has been modified to make this correction. It now correctly says "southeastern corner." The revised Form 1 is in the following location: **Attachments\Form 1\Form 1_Cypress I-1 Class VI_Application.pdf**

**Response to Specific Comments, SC-26 (Cypress and Old Barberry Only)**

**Tallgrass Cypress M-2 Daily Drilling Report (dated 1-24 & 1-25).pdf**

# 1 General

## 1.1 Customer Information

| | |
|---|---|
| **Company** | Tallgrass |
| **Representative** | |
| **Address** | |

## 1.2 Well/Wellbore Information

| | | | |
|---|---|---|---|
| **Well** | Cypress M-2 | **Wellbore No.** | |
| **Well Name** | Cypress M-2 | **Wellbore Name** | Cypress M-2 |
| **Report no.** | 26 | **Report date** | 1/23/2024 |
| **Project** | Drilling | **Site** | Trailblazer - WY |
| **Rig Name/No.** | Rig #38/38 | **Event** | ORIG DRILLING |
| **Start date** | 12/14/2023 | **End date** | |
| **Spud date** | 12/14/2023 | **UWI** | Cypress M-2 |
| **Afe No.** | 724-000037 | | |
| **Active datum** | RKB @5,249.5ft (above Ground Level) | | |
| **API no.** | 49-021-29598-00 | **Block** | |
| **Supervisor** | Ricardo Mendez | **Engineer** | Ricardo Mendez |

## 1.3 Depth Days

| | | | |
|---|---|---|---|
| **MD** | 9,081.0 (ft) | **TVD** | |
| **Progress** | | **Avg. ROP** | 0.0 (ft/hr) |
| **Rotating hours** | | **Cum Rot Hrs** | 126.00 (hr) |
| **DFS** | 21.00 (days) | **Est days** | |
| **MD auth** | 9,088.0 (ft) | | |
| **Last Casing** | | | |

## 1.4 Status

| | |
|---|---|
| **Current status** | Waiting on cement to reach 500 psi. cs. at 8100', circulating with 100 gpm. no issues. |
| **24 hr summary** | P/U DP, circulate, tag bottom, spot 12 bbl waterbased mud pill, L/D 5 jts, spot #8 cement plug, L/D 15 jts. of DP,<br>Circulate & wait on cement to reach 500 cs, no issues while circulating |
| **24 hr forecast** | Continue P&A operations |

## 1.5 Costs

| | | | |
|---|---|---|---|
| **Daily cost** | 57,378.63 $ | **Authorized cost** | |
| **Cumulative total** | 2,731,122.89 $ | **Expenditure** | |

# 2 Operation Summary

## 2.1 Operation Summary

| From | To | Dur. (hr) | Phase | Code | Sub | Class | MD from (ft) | MD to (ft) | Operation |
|---|---|---|---|---|---|---|---|---|---|
| 6:00 | 8:00 | 2.00 | DRLPRO | 06 | | P | 8,031.0 | 9,084.0 | P/U 34 jts DP, No displacement issues |
| 8:00 | 9:45 | 1.75 | DRLPRO | 05 | | P | 9,081.0 | 9,081.0 | Circulate B/U @ 200 gpm. No circulation issues, Tag bottom @ 9084' |
| 9:45 | 10:30 | 0.75 | DRLPRO | 05 | | P | 9,081.0 | 9,081.0 | Spot 12 bbl pill for plug / 13.5 MW, 21 PV, 59 YP. Pumped 143 stks of pill followed by 1850 stks OBM |
| 10:30 | 11:00 | 0.50 | DRLPRO | 06 | | P | 9,081.0 | 8,944.0 | L/D 5 jts DP to 8944'. Plug to be set @ 8944' for tool jt positioning. Top of cement plug @ 8426' |
| 11:00 | 13:00 | 2.00 | DRLPRO | 05 | | U | 8,944.0 | 8,944.0 | Circulate & Wait for DP circulating swage. Circulate @ 95 gpm w/ 225 psi |
| 13:00 | 13:30 | 0.50 | DRLPRO | 12 | | P | 8,944.0 | 8,944.0 | PJSM w/ rig crews & Schlumberger. R/U DP swage and cement lines then begin plugging operations |
| 13:30 | 15:00 | 1.50 | DRLPRO | 12 | | P | 8,944.0 | 8,944.0 | Pressure test lines to 4000psi - Test good. Plug #8 - Pump 30 bbls 12 ppg @ 4 bpm w/ 200 psi, drop bottom plug ball, Pump 39 bbls 15.8ppg EverCRETE @ 4.2bpm w/ 434psi, Drop top plug ball, Pump 10 bbls 12ppg @ 4.2bpm w/ 405psi, Displace w/ 135 bbls OBM @ 6.4bpm w/ 776psi. Finished #8 plug @ 15:05hrs. |

### 2.1 Operation Summary (Continued)

| From | To | Dur. (hr) | Phase | Code | Sub | Class | MD from (ft) | MD to (ft) | Operation |
|---|---|---|---|---|---|---|---|---|---|
| 15:00 | 16:30 | 1.50 | DRLPRO | 06 | | P | 8,944.0 | 8,100.0 | L/D 15 jts DP, TOOH F/8478'-T/8100' @ 30 fpm. No overpull issues while TOOH. Out of plug @ 16:15hrs |
| 16:30 | 18:00 | 1.50 | DRLPRO | 05 | | P | 8,100.0 | 8,100.0 | Circulate & wait on cement to reach 500 cs @ 8100' w/ 100gpm & 125 psi. No losses while circulating. |
| 18:00 | 22:00 | 4.00 | DRLPRO | 05 | | P | 8,100.0 | 8,100.0 | Circulate & wait on cement to reach 500 cs @ 8100' w/ 100gpm & 125 psi. No losses while circulating. |
| 22:00 | 2:00 | 4.00 | DRLPRO | 05 | | P | 8,100.0 | 8,100.0 | Circulate & wait on cement to reach 500 cs @ 8100' w/ 100gpm & 125 psi. No losses while circulating. |
| 2:00 | 6:00 | 4.00 | DRLPRO | 05 | | P | 8,100.0 | 8,100.0 | Circulate & wait on cement to reach 500 cs @ 8100' w/ 100gpm & 125 psi. No losses while circulating. |

## 3 Hole Sections

### 3.1 Hole Sections

| Wellbore Name / Wellbore No. | Section Name | Section type | Effective hole diameter (in) | ID (in) | MD (ft) | | Hole section start date/time | Hole section end date/time |
|---|---|---|---|---|---|---|---|---|
| | | | | | Top | Base | | |
| Cypress M-2 / | Conductor | Open Hole | | | 0.0 | 103.0 | 12/14/2023 12:00AM | 12/15/2023 12:00AM |
| Cypress M-2 / | Surface | Open Hole | 12.250 | | 103.0 | 1,566.0 | 1/4/2024 4:00AM | 1/5/2024 5:00PM |
| Cypress M-2 / | Production | Casing | 8.835 | 8.835 | -3.0 | 1,553.5 | 1/7/2024 12:00AM | 1/18/2024 11:00PM |
| Cypress M-2 / | | Open Hole | 8.750 | 8.750 | 1,553.5 | 9,081.0 | 1/7/2024 12:00AM | 1/18/2024 11:00PM |

## 4 Fluids

### 4.1 Mud

| Daily mud | 0.00 ($) | Cum. mud cost | 0.00 ($) |
|---|---|---|---|

| Mud desc. | Density (ppg) | Viscosity (s/qt) | Date/Time | MD check (ft) | PV (cp) | YP (lbf/100ft²) | Cl- (ppm) | Ca+ (ppm) | pH | Pm | Pf (cc) | Mf (cc) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OIL (REGULAR) | 9.40 | 72.00 | 1/22/2024 15:00 | 9,081.0 | 16.00 | 12.000 | | | | | | |
| OIL (REGULAR) | 9.40 | 78.00 | 1/23/2024 4:00 | 9,081.0 | 18.00 | 12.000 | | | | | | |
| OIL (REGULAR) | 9.40 | 69.00 | 1/23/2024 15:00 | 9,081.0 | 16.00 | 12.000 | | | | | | |
| OIL (REGULAR) | 9.40 | 63.00 | 1/24/2024 4:00 | 9,081.0 | 16.00 | 12.000 | | | | | | |

## 5 Fluid Management

### 5.1 Fluid Losses

| Total | | Surface | | | Sub Surface | | |
|---|---|---|---|---|---|---|---|
| Mud start | 0.00 | | Daily | Cum | | Daily | Cum |
| Dumped | | Shakers | | 0.00 | Lost circulation | | 0.00 |
| Returned | | Cleaner | | 0.00 | Running casing | | 0.00 |
| Subsurface total | | Centrifuge | | 0.00 | Cement casing | | 0.00 |
| Subsurface total | | Pits | | 0.00 | Behind casing | | 0.00 |
| Built | | Tripping | | 0.00 | Abandon | | 0.00 |
| Received | | Evaporation | | 0.00 | Formation | | 0.00 |
| End vol. | 0.00 | Spills | | 0.00 | Seepage | | 0.00 |
| Losses Detail | | Dewatering | | 0.00 | Other 1 | | 0.00 |
| Top of loss zone | | Other 1 | | 0.00 | Subsurface total | | 0.00 |
| Base of loss zone | | Gain | | 0.00 | | | |
| | | Surface total | | 0.00 | | | |

## 5.2 Fluid Volumes

### 5.2.1 Annular Volumes

| Description | Volume (bbl) |
|---|---|
| | |

Total annular vol. (bbl):

### 5.2.2 String Volumes

| Description | Volume (bbl) |
|---|---|
| | |

**Total string vol. (bbl):**

### 5.2.3 Pit Volumes

| Name | Install date | Removal date | Capacity (bbl) | Time | Mud density (ppg) | Active | Viscosity (s/qt) | Volume (bbl) |
|---|---|---|---|---|---|---|---|---|
| Shaker Tank | | | 651.00 | | | | | |
| Suction Tank | | | 634.00 | | | | | |

**Total pit vol.:**
**Total active pit vol.:**
**Total system vol.:**

# 6 Drillstrings

# 7 Pump Operations

## 7.1 Pump/Hydraulics

| No. | Make/Model | Stroke (in) | Liner size (in) | Efficiency (%) | Pressure (psi) | SPM (spm) | Output (gpm) | Kill SPM/Pressure/Depth (spm/psi/ft) |
|---|---|---|---|---|---|---|---|---|
| 1 | CONTINENTAL-EMSCO / FB-1600 | 12.00 | | | | | | |
| 2 | CONTINENTAL-EMSCO / FB-1600 | 12.00 | | | | | | |
| 3 | CONTINENTAL-EMSCO / FB-1600 | 12.00 | | | | | | |

# 8 Surveys

## 8.1 Surveys

| MD (ft) | Inc. (°) | Azi. (°) | TVD (ft) | N/S (ft) | E/W (ft) | V. sec. (ft) | Dleg (°/100ft) | Survey tool |
|---|---|---|---|---|---|---|---|---|
| 8,531.0 | 0.79 | 246.01 | 8,530.4 | -41.6 | 21.0 | -41.6 | 0.59 | |

# 9 Mud Inventory

## 9.1 Mud Products

| Product | Units | Used | Day cost ($) | Quantity end |
|---|---|---|---|---|
| | | | 0.00 | 0.00 |

# 10 Safety

## 10.1 Status

| | | | |
|---|---|---|---|
| **DSLTI** | | **DSLTA** | |
| **STOP Cards** | 1.00 | | |

## 10.2 Safety Moment

| | |
|---|---|
| **Topic** | Leak on pipe cat |
| **Comments** | stopped operations, addressed the issue, continued operations |

## 10.3 Inspections/Drills

| | | | |
|---|---|---|---|
| **Drill type** | | **Last pit drill** | |
| **Last drill** | | **Last diverter drill** | |
| **Last fire/boat drill** | | **Last H2S drill** | |
| **Last evacuation drill** | | **Last trip drill** | |
| **Last weekly rig check** | | **Test COM.** | |
| **Daily inspection done** | | **Ton miles** | |

| | | | |
|---|---|---|---|
| **Last safety inspection** | | **Last Csg Press Test** | |
| **Last safety meeting** | | **Last Csg Press** | |

### 10.4 BOP Tests

| | | | |
|---|---|---|---|
| **Last BOP pressure test** | | **Next test due** | |
| **Last BOP function test** | | **Last BOP drill** | |

### 10.5 Pressure Tests

| | | | |
|---|---|---|---|
| **Standpipe manifold** | | **Kelly hose** | |
| **Diverter pressure** | | **Annular press** | |
| **Upper rams** | | **Lower rams** | |
| **Choke line** | | **Choke manifold** | |
| **Kill line** | | | |

### 10.6 Incidents

| Report date | Reporter | Company responsible | No. of minor injures | No. of major injures | No. of fatalities | Cause | Incident desc. |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

## 11 Personnel

### 11.1 Personnel

Total No. of People: 18

| Company | No. People | Company | No. People |
|---|---|---|---|
| Tres Management | 3 | Kayen Industries | 1 |
| True Drilling | 10 | Halliburton | 1 |
| Schlumberger Cementers | 3 | | |

## 12 Materials

### 12.1 Materials

| Product name | Weight/Vol. per unit | Usage | Quantity end | Product name | Weight/Vol. per unit | Usage | Quantity end |
|---|---|---|---|---|---|---|---|
| DIESEL | 7.10 (Gal) | 898.00 | 6,038.00 | WATER, DRILLING | 7.10 (bbl) | | 2,950.00 |
| MUD DIESEL | 7.10 (Gal.) | | 3,000.00 | | | | |

## 13 Weather

### 13.1 Weather

| | | | |
|---|---|---|---|
| **Time** | 02:00 | **Weather** | Mostly Clear |
| **Daily High/Low Temp** | 45.00(°F) / 24.00(°F) | **Visibility** | 11.00 (mi) |
| **Ceiling** | (ft) | **10M wind spd.** | 9.0 (knots) |
| **Gust spd** | 17.0 (knots) | | |
| **Comments** | | | |

| Currents | | SIG/MAX Wave | | | Swell | Vessel | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Speed (knots) | Dir (°) | Ht. (ft) | Dir (°) | Period (sec) | Ht. (ft) | Heave (ft) | Pitch (°) | Roll (°) | Offset (ft) | Heading (°) |
| | | / | / | / | | | | | | |

# 1 General

## 1.1 Customer Information

| | |
|---|---|
| **Company** | Tallgrass |
| **Representative** | |
| **Address** | |

## 1.2 Well/Wellbore Information

| | | | |
|---|---|---|---|
| **Well** | Cypress M-2 | **Wellbore No.** | |
| **Well Name** | Cypress M-2 | **Wellbore Name** | Cypress M-2 |
| **Report no.** | 27 | **Report date** | 1/24/2024 |
| **Project** | Drilling | **Site** | Trailblazer - WY |
| **Rig Name/No.** | Rig #38/38 | **Event** | ORIG DRILLING |
| **Start date** | 12/14/2023 | **End date** | |
| **Spud date** | 12/14/2023 | **UWI** | Cypress M-2 |
| **Afe No.** | 724-000037 | | |
| **Active datum** | RKB @5,249.5ft (above Ground Level) | | |
| **API no.** | 49-021-29598-00 | **Block** | |
| **Supervisor** | Ricardo Mendez | **Engineer** | Ricardo Mendez |

## 1.3 Depth Days

| | | | |
|---|---|---|---|
| **MD** | 9,081.0 (ft) | **TVD** | |
| **Progress** | | **Avg. ROP** | 0.0 (ft/hr) |
| **Rotating hours** | | **Cum Rot Hrs** | 126.00 (hr) |
| **DFS** | 22.00 (days) | **Est days** | |
| **MD auth** | 9,088.0 (ft) | | |
| **Last Casing** | | | |

## 1.4 Status

| | |
|---|---|
| **Current status** | |
| **24 hr summary** | Set abandonment plugs |
| **24 hr forecast** | Flush BOP, wellhead, N/D BOP, cut casing 6' below ground level. weld on Name plate. RDMO |

## 1.5 Costs

| | | | |
|---|---|---|---|
| **Daily cost** | 65,440.00 $ | **Authorized cost** | |
| **Cumulative total** | 2,796,562.89 $ | **Expenditure** | |

# 2 Operation Summary

## 2.1 Operation Summary

| From | To | Dur. (hr) | Phase | Code | Sub | Class | MD from (ft) | MD to (ft) | Operation |
|---|---|---|---|---|---|---|---|---|---|
| 6:00 | 7:30 | 1.50 | CSGPRO | 13 | | P | 8,100.0 | 8,100.0 | Wait on #8 cement plug |
| 7:30 | 8:30 | 1.00 | CSGPRO | 06 | | U | 8,100.0 | 8,202.0 | TIH f/8100'-t/8202' Tag up @ 8202' stack 10k on bridge. Pick up & circulate, wash through bridge @ 8202', TIH w/ DP. |
| 8:30 | 9:45 | 1.25 | CSGPRO | 06 | | P | 8,202.0 | 8,365.0 | TIH f/8202'-t/8365' Tag up @ 8365' quill up and pump @ 105 gpm. Tag 8365' w/ pump. P/U & tag 3 times to ensure good plug top. P/U to 8311' |
| 9:45 | 10:00 | 0.25 | CSGPRO | 12 | | P | 8,311.0 | 8,311.0 | PJSM w/ Schlumberger & R/U cement equipment to pump plug #7 f/ 8311'- t/ 7561' (750' plug) |
| 10:00 | 11:00 | 1.00 | CSGPRO | 12 | | P | 8,311.0 | 8,311.0 | Plug #7<br>Pressure test cement lines @ 1000/2000psi - test good. Pump 18 bbls 12ppg MPE @ 3.3bpm w/300psi, Drop bottom plug ball, Pump 59 bbls/215sks (Class G) plug cement - 15.8ppg, 1.53 yield, 6.271 gals/sk H2O @ 4.6 bpm w/ 452psi, Drop top plug ball, Pump 9 bbls 12ppg MPE @ 4.2 bpm w/ 271psi, Displace w/ 120 bbls OBM @ 6.4 bpm w/ 427psi. for plug placement f/ 8311'- t/ 7561' (750' plug) |
| 11:00 | 12:30 | 1.50 | CSGPRO | 06 | | P | 8,311.0 | 7,392.0 | LDDP f/8311'-t/7392' No issues |
| 12:30 | 13:00 | 0.50 | CSGPRO | 05 | | P | 7,392.0 | 7,392.0 | Break Circulation, Pump 19 bbls weighted high vis pill 227stks @ |

## 2.1 Operation Summary (Continued)

| From | To | Dur. (hr) | Phase | Code | Sub | Class | MD from (ft) | MD to (ft) | Operation |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 211gpm. Spot pill on bottom with 1571 stks of OBM |
| 13:00 | 13:30 | 0.50 | CSGPRO | 06 | | P | 7,392.0 | 7,142.0 | LDDP f/7392'-t/7142' No losses or displacement issues |
| 13:30 | 14:00 | 0.50 | CSGPRO | 12 | | P | 7,142.0 | 7,142.0 | PJSM w/ Schlumberger & R/U cement equipment to pump plug #6 Plug f/7142'-t/6984' (158' plug) |
| 14:00 | 15:00 | 1.00 | CSGPRO | 12 | | P | 7,142.0 | 7,142.0 | Plug #6<br>Pressure test cement lines @ 1000/2000psi - test good. Pump 18 bbls 12ppg MPE @ 4.2bpm w/286psi, Drop bottom plug ball, Pump 12 bbls/58 sks (Class G) plug cement - 15.8ppg, 1.16 yield, 5.045 gals/sk H2O @ 2.2 bpm w/ 81psi, Drop top plug ball, Pump 7 bbls 12ppg MPE @ 5.5 bpm w/ 344psi, Displace w/ 105 bbls OBM @ 4.9 bpm w/ 316psi. for plug placement f/ 6994'-t/ 7152' (158' plug) |
| 15:00 | 15:30 | 0.50 | CSGPRO | 06 | | P | 7,142.0 | 6,898.0 | LDDP f/7142'-t/6898' No losses or displacement issues |
| 15:30 | 16:00 | 0.50 | CSGPRO | 05 | | P | 6,898.0 | 6,898.0 | Break Circulation @ 6898', Pump 12 bbls weighted high vis pill 143 stks @ 211gpm. Spot pill on bottom with 1366 stks of OBM |
| 16:00 | 16:30 | 0.50 | CSGPRO | 06 | | P | 6,898.0 | 6,748.0 | LDDP f/6898'-t/6748' No losses or displacement issues |
| 16:30 | 16:45 | 0.25 | CSGPRO | 12 | | P | 6,748.0 | 6,748.0 | PJSM w/ Schlumberger & R/U cement equipment to pump plug #5 Plug f/6748'-t/6648' (100' plug) |
| 16:45 | 17:30 | 0.75 | CSGPRO | 12 | | P | 6,748.0 | 6,748.0 | Plug #5<br>Pressure test cement lines @ 1000/2000psi - test good. Pump 18 bbls 12ppg MPE @ 2.4bpm w/153psi, Drop bottom plug ball, Pump 7.8 bbls/38 sks (Class G) plug cement - 15.8ppg, 1.16 yield, 5.053 gals/sk H2O @ 2.8 bpm w/ 96psi, Drop top plug ball, Pump 7 bbls 12ppg MPE @ 2.5 bpm w/ 83psi, Displace w/ 102 bbls OBM @ 5.5 bpm w/ 516psi. for plug placement f/ 6748'-t/ 6648' (100' plug) |
| 17:30 | 18:30 | 1.00 | CSGPRO | 06 | | P | 6,748.0 | 5,892.0 | LDDP f/6748-t/5892' No losses or displacement issues |
| 18:30 | 19:00 | 0.50 | CSGPRO | 05 | | P | 5,892.0 | 5,892.0 | Break Circulation @ 5892', Pump 38 bbls weighted high vis pill 453 stks @ 211gpm. Spot pill on bottom with 1090 stks of OBM |
| 19:00 | 19:30 | 0.50 | CSGPRO | 06 | | P | 5,892.0 | 5,382.0 | LDDP f/5892'-t/5382' @60 fpm. No losses or displacement issues |
| 19:30 | 20:00 | 0.50 | CSGPRO | 12 | | P | 5,382.0 | 5,382.0 | PJSM w/ Schlumberger & R/U cement equipment to pump plug #4 Plug f/5382'-t/5186' (200' plug) |
| 20:00 | 21:00 | 1.00 | CSGPRO | 12 | | P | 5,382.0 | 5,382.0 | Plug #4,<br>Pressure test cement lines @ 1000/2000psi - test good. Pump 18 bbls 12ppg MPE @ 2.2 bpm w/331 psi, Drop bottom plug ball, Pump 16 bbls/38 sks (Class G) plug cement - 15.8ppg, 1.16 yield, 5.07 gals/sk H2O @ 2.8 bpm w/ 96psi, Drop top plug ball, Pump 7.8 bbls 12ppg MPE @ 2.1 bpm w/ 98 psi, Displace w/ 102 bbls OBM @ 5.5 bpm w/ 594psi. for plug placement f/5382'-t/5186' (200' plug) |
| 21:00 | 22:00 | 1.00 | CSGPRO | 06 | | P | 5,382.0 | 4,034.0 | LDDP f/5382' to 4034', @60. fpm, No losses or displacement issues |
| 22:00 | 22:30 | 0.50 | CSGPRO | 05 | | P | 4,034.0 | 4,034.0 | Break cirulation@4034', Pump 38 bbs. (500') weighted high vis pill, 453 stks, @211 gpm, Spot pill on bottom with 748 stks. OBM |
| 22:30 | 23:00 | 0.50 | CSGPRO | 06 | | P | 4,034.0 | 3,530.0 | LDDP from 4034' to 3530' @60. fpm No losses or displacement issues |
| 23:00 | 23:30 | 0.50 | CSGPRO | 12 | | P | 3,530.0 | 3,530.0 | PJSM w/Schlumberger & R/U cement equipment to pump plug #3 Plug f/3530' to 3430' (100' plug) |
| 23:30 | 0:00 | 0.50 | CSGPRO | 12 | | P | 3,530.0 | 3,530.0 | Plug #3<br>Pressure test cement lines @ 1000/2000psi - test good. Pump 18 bbls 12ppg MPE @ 4.2 bpm w/302 psi, Drop bottom plug ball, Pump 8 bbls/ 58 sks (Class G) plug cement - 15.8ppg, 1.16 yield, 5.07 gals/sk H2O @ 2.5 bpm w/ 80 psi, Drop top plug ball, Pump 7 bbls 12ppg MPE @ 2.4 bpm w/ 80 psi, Displace w/ 50 bbls OBM @ 5.3 bpm w/ 350 psi. for plug placement f/3530' to 3430' (100' plug) |
| 0:00 | 1:15 | 1.25 | CSGPRO | 06 | | P | 3,530.0 | 2,143.0 | LDDP f/3530' to 2143', @60 fpm. No losses or displacement issues |
| 1:15 | 1:45 | 0.50 | CSGPRO | 05 | | P | 2,143.0 | 2,143.0 | Break cirulation@ 2143', Pump 38 bbs. (500') weighted high vis pill, 453 stks, @211 gpm, Spot pill on bottom |
| 1:45 | 2:00 | 0.25 | CSGPRO | 06 | | P | 1,669.0 | 2,143.0 | LDDP f/2143' to 1669", @30 to 60 fpm. No losses or displacement issues |
| 2:00 | 2:15 | 0.25 | CSGPRO | 12 | | P | 1.0 | 1,669.0 | PJSM w/Schlumberger & R/U cement equipment to pump plug #2 Plug f/1660' to 1410' (250' plug) |
| 2:15 | 3:15 | 1.00 | CSGPRO | 12 | | P | 1,669.0 | 1,669.0 | Plug #2<br>Pressure test cement lines @ 1000/2000psi - test good. Pump 18 bbls 12ppg MPE @ 4.2 bpm w/230psi, Drop bottom plug ball, Pump 8 bbls/93 sks (Class G) plug cement - 15.8ppg, 1.16 yield, 5.08 gals/sk H2O @ 2.3 bpm w/130 psi, Drop top plug ball, Pump 7 bbls 12ppg MPE @ 2.5 bpm w/ 91 psi, Displace w/ 10 bbls OBM @ 2 bpm w/91 psi. for plug placement f/1660 to 1410' (250' plug) NOTE: Had trouble getting air from bulk truck. |
| 3:15 | 4:15 | 1.00 | CSGPRO | 06 | | P | 691.0 | 1,669.0 | LDDP f/1669' to 691', @ 30 to 60 fpm. No losses or displacement issues |
| 4:15 | 4:30 | 0.25 | CSGPRO | 05 | | P | 691.0 | 691.0 | Break cirulation@ 691', Pump 38 bbs. (500') weighted high vis pill, 453 stks, @211 gpm, Spot pill on bottom |
| 4:30 | 5:00 | 0.50 | CSGPRO | 06 | | P | 200.0 | 691.0 | LDDP f/691' to 200', @ 30 to 60 fpm. No losses or displacement issues |
| 5:00 | 5:15 | 0.25 | CSGPRO | 12 | | P | 200.0 | 200.0 | PJSM w/Schlumberger & R/U cement equipment to pump plug #1 Plug |

### 2.1 Operation Summary (Continued)

| From | To | Dur. (hr) | Phase | Code | Sub | Class | MD from (ft) | MD to (ft) | Operation |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | f/200' to 0' (200' plug) |
| 5:15 | 6:00 | 0.75 | CSGPRO | 12 | | P | 0.0 | 200.0 | Plug #1<br>Pressure test cement lines @ 1000/2000psi - test good. Pump 18 bbls 12ppg MPE @ 2.4bpm w/90 psi. Pump 15.2 bbls/76 sks (Class G Neat) plug cement - 15.8ppg, 1.16 yield, 5.07 gals/sk H2O @ 2.4 bpm w/ 119psi, Displace 3 bbls w/ water @ 2.4 bpm w/125 psi. for plug placement f/200 to 0' (200' plug). NOTE 5 bbls of cement back at surface. |

## 3 Hole Sections

### 3.1 Hole Sections

| Wellbore Name / Wellbore No. | Section Name | Section type | Effective hole diameter (in) | ID (in) | MD (ft) | | Hole section start date/time | Hole section end date/time |
|---|---|---|---|---|---|---|---|---|
| | | | | | Top | Base | | |
| Cypress M-2 / | Conductor | Open Hole | | | 0.0 | 103.0 | 12/14/2023 12:00AM | 12/15/2023 12:00AM |
| Cypress M-2 / | Surface | Open Hole | 12.250 | | 103.0 | 1,566.0 | 1/4/2024 4:00AM | 1/5/2024 5:00PM |
| Cypress M-2 / | Production | Casing | 8.835 | 8.835 | -3.0 | 1,553.5 | 1/7/2024 12:00AM | 1/18/2024 11:00PM |
| Cypress M-2 / | | Open Hole | 8.750 | 8.750 | 1,553.5 | 9,081.0 | 1/7/2024 12:00AM | 1/18/2024 11:00PM |

## 4 Fluids

### 4.1 Mud

| Daily mud | 0.00 ($) | Cum. mud cost | 0.00 ($) |
|---|---|---|---|

| Mud desc. | Density (ppg) | Viscosity (s/qt) | Date/Time | MD check (ft) | PV (cp) | YP (lbf/100ft²) | Cl- (ppm) | Ca+ (ppm) | pH | Pm | Pf (cc) | Mf (cc) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OIL (REGULAR) | 9.40 | 63.00 | 1/24/2024 4:00 | 9,081.0 | 16.00 | 12.000 | | | | | | |

## 5 Fluid Management

### 5.1 Fluid Losses

| Total | | Surface | | | Sub Surface | | |
|---|---|---|---|---|---|---|---|
| Mud start | 0.00 | | Daily | Cum | | Daily | Cum |
| Dumped | | Shakers | | 0.00 | Lost circulation | | 0.00 |
| Returned | | Cleaner | | 0.00 | Running casing | | 0.00 |
| Subsurface total | | Centrifuge | | 0.00 | Cement casing | | 0.00 |
| Subsurface total | | Pits | | 0.00 | Behind casing | | 0.00 |
| Built | | Tripping | | 0.00 | Abandon | | 0.00 |
| Received | | Evaporation | | 0.00 | Formation | | 0.00 |
| End vol. | 0.00 | Spills | | 0.00 | Seepage | | 0.00 |
| Losses Detail | | Dewatering | | 0.00 | Other 1 | | 0.00 |
| Top of loss zone | | Other 1 | | 0.00 | Subsurface total | | 0.00 |
| Base of loss zone | | Gain | | 0.00 | | | |
| | | Surface total | | 0.00 | | | |

## 5.2 Fluid Volumes

### 5.2.1 Annular Volumes

| Description | Volume (bbl) |
|---|---|
| | |

**Total annular vol. (bbl):**

### 5.2.2 String Volumes

| Description | Volume (bbl) |
|---|---|
| | |

**Total string vol. (bbl):**

### 5.2.3 Pit Volumes

| Name | Install date | Removal date | Capacity (bbl) | Time | Mud density (ppg) | Active | Viscosity (s/qt) | Volume (bbl) |
|---|---|---|---|---|---|---|---|---|
| Shaker Tank | | | 651.00 | | | | | |
| Suction Tank | | | 634.00 | | | | | |

**Total pit vol.:**
**Total active pit vol.:**
**Total system vol.:**

## 6 Drillstrings

## 7 Pump Operations

### 7.1 Pump/Hydraulics

| No. | Make/Model | Stroke (in) | Liner size (in) | Efficiency (%) | Pressure (psi) | SPM (spm) | Output (gpm) | Kill SPM/Pressure/Depth (spm/psi/ft) |
|---|---|---|---|---|---|---|---|---|
| 1 | CONTINENTAL-EMSCO / FB-1600 | 12.00 | | | | | | |
| 2 | CONTINENTAL-EMSCO / FB-1600 | 12.00 | | | | | | |
| 3 | CONTINENTAL-EMSCO / FB-1600 | 12.00 | | | | | | |

## 8 Surveys

### 8.1 Surveys

| MD (ft) | Inc. (°) | Azi. (°) | TVD (ft) | N/S (ft) | E/W (ft) | V. sec. (ft) | Dleg (°/100ft) | Survey tool |
|---|---|---|---|---|---|---|---|---|
| 8,531.0 | 0.79 | 246.01 | 8,530.4 | -41.6 | 21.0 | -41.6 | 0.59 | |

## 9 Mud Inventory

### 9.1 Mud Products

| Product | Units | Used | Day cost ($) | Quantity end |
|---|---|---|---|---|
| | | | 0.00 | 0.00 |

## 10 Safety

### 10.1 Status

| | | | |
|---|---|---|---|
| **DSLTI** | | **DSLTA** | |
| **STOP Cards** | 0.00 | | |

### 10.2 Safety Moment

| | |
|---|---|
| **Topic** | |
| **Comments** | |

### 10.3 Inspections/Drills

| | | | |
|---|---|---|---|
| **Drill type** | | **Last pit drill** | |
| **Last drill** | | **Last diverter drill** | |
| **Last fire/boat drill** | | **Last H2S drill** | |
| **Last evacuation drill** | | **Last trip drill** | |
| **Last weekly rig check** | | **Test COM.** | |
| **Daily inspection done** | | **Ton miles** | |
| **Last safety inspection** | | **Last Csg Press Test** | |
| **Last safety meeting** | | **Last Csg Press** | |

### 10.4 BOP Tests

| | | | |
|---|---|---|---|
| **Last BOP pressure test** | | **Next test due** | |

| | | | |
|---|---|---|---|
| **Last BOP function test** | | **Last BOP drill** | |

### 10.5 Pressure Tests

| | | | |
|---|---|---|---|
| **Standpipe manifold** | | **Kelly hose** | |
| **Diverter pressure** | | **Annular press** | |
| **Upper rams** | | **Lower rams** | |
| **Choke line** | | **Choke manifold** | |
| **Kill line** | | | |

### 10.6 Incidents

| Report date | Reporter | Company responsible | No. of minor injures | No. of major injures | No. of fatalities | Cause | Incident desc. |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

## 11 Personnel

### 11.1 Personnel

Total No. of People: 18

| Company | No. People | Company | No. People |
|---|---|---|---|
| Halliburton | 1 | Tres Management | 3 |
| Schlumberger Cementers | 3 | True Drilling | 10 |
| Kayen Industries | 1 | | |

## 12 Materials

### 12.1 Materials

| Product name | Weight/Vol. per unit | Usage | Quantity end | Product name | Weight/Vol. per unit | Usage | Quantity end |
|---|---|---|---|---|---|---|---|
| DIESEL | 7.10 (Gal) | 1,685.00 | 4,353.00 | WATER, DRILLING | 7.10 (bbl) | | 2,950.00 |
| MUD DIESEL | 7.10 (Gal.) | | 3,000.00 | | | | |

## 13 Weather

### 13.1 Weather

| | | | |
|---|---|---|---|
| **Time** | 00:00 | **Weather** | Mostly Clear |
| **Daily High/Low Temp** | 45.00(°F) / 25.00(°F) | **Visibility** | 16.00 (mi) |
| **Ceiling** | (ft) | **10M wind spd.** | 6.0 (knots) |
| **Gust spd** | 9.0 (knots) | | |
| **Comments** | Wind chill 19 | | |

| Currents | | SIG/MAX Wave | | | Swell | Vessel | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Speed (knots) | Dir (°) | Ht. (ft) | Dir (°) | Period (sec) | Ht. (ft) | Heave (ft) | Pitch (°) | Roll (°) | Offset (ft) | Heading (°) |
| | | / | / | / | | | | | | |

**Response to Specific Comments, SC-26 (Cypress and Old Barberry Only)**

**Cypress M-2 WBD - PLUG AND ABANDONMENT - 1-22-24.pdf**

# STRATIGRAPHY WELL: CYPRESS M-2
# PLUG & ABANDON

TALLGRASS
Leading Energy Solutions

| | | | | X | Y | LAT | LONG | CRS | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **API** | **49-021-29598-00** | | | | | | | | **STATE** | WYOMING |
| **Rig Floor (ft)** | **25.5** | | **SHL** | 3519581.96 | 14996069.25 | 41°05'18.2698"N | 104°10'58.0463"W | WGS 84 | **COUNTY** | LARAMIE |
| | 0 | | **BHL** | 3519581.96 | 14996069.25 | 41°05'18.2698"N | 104°10'58.0463"W | WGS 84 | **TN \| R \| SEC** | 13N, 61W, 14 |

| | | | | |
|---|---|---|---|---|
| | **103.5** | PLUG 1: SURFACE PLUG<br>O' - 200'<br>CLASS G @15.8lb/gal | **16in Conductor @ 103.5 FT** | HOLE $OD_{IN}$<br>20 |
| Fox Hills | 834.3 SS | | | |
| Pierre | 1001.7 SH | Plug 2: SURFACE CASING PLUG<br>1402' TO 1652'<br>250' PLUG<br>CLASS G @15.8lb/gal | | HOLE $OD_{IN}$ |
| **Hole TD** | **1566.0 FT** | | **9-5/8in 40lb/ft J55 LTC @1551.5 FT** | 12.25 |
| | | PLUG 3: ISOLATION PLUG<br>3419' - 3519 (100' PLUG)<br>CLASS G @15.8lb/gal | | |
| Shannon | 5286.2 SS | PLUG 4: SHANNON PLUG<br>5186' - 5386 (200' PLUG)<br>CLASS G @15.8lb/gal | | |
| Niobrara | 6697.7 Shale | PLUG 5: NIOBRARA PLUG<br>6648' - 6748 (100' PLUG)<br>CLASS G @15.8lb/gal | | |
| Codell | 7034.9 SS | | | |
| Greenhorn | 7091.9 Shale | PLUG 6: CODELL PLUG<br>6984' TO 7142' (158' PLUG)<br>CLASS G @15.8lb/gal | | |
| Graneros | 7403.0 Shale | | | |
| Huntsman | 7559.9 SS | | | |
| J Sand | 7641.9 SS | PLUG 7: SUNDANCE-DAKOTA-<br>J SAND PLUG<br>7561' - 8311'<br>750' PLUG<br>CLASS G @15.8lb/gal | | |
| Skull Creek | 7721.2 Shale | | | |
| Dakota_FS | 7880.6 SS/Shale | | | |
| Morrison | 8029.1 SS/Shale | | | |
| Sundance_SS | 8261.0 SS | | | |
| Chugwater | 8322.9 Shale | | | |
| Goose Egg (Lykins) | 8554.3 Shale | PLUG 8: CO2 Resistant Cement<br>Lyons Plug<br>8428' - 8928'<br>500' PLUG | | |
| Lyons | 8809.2 SS | | | |
| Satanka | 8878.1 Shale | | | |
| | | CO2 RESISTANT CEMENT<br>EVERCRETE @15.8lb/gal<br>TAGGED WITH 10klbs WOB<br>AFTER 500psi CS REACHED | | HOLE $OD_{IN}$ |
| **Well TD** | **9081.0 FT** | | | 8.75 |

| CASING SECTION | DRILL HOLE $INTERVAL_{FT}$ | DRILL HOLE $LENGTH_{FT}$ | DRILL HOLE $ID_{IN}$ | $OD_{IN}$ | $ID_{IN}$ | $WT_{LB/FT}$ | WALL $TH_{IN}$ | DRIFT $ID_{IN}$ | GRADE | CONNECTION | CONNECTION $OD_{IN}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CONDUCTOR | 0 - 103.5 | 0 | 20 | | | | | | | | |
| SURFACE | 0 - 1566 | 1566 | 12.25 | 9.625 | 8.835 | 40 | 0.395 | 8.679 | J55 | LTC | 10.625 |
| OPEN HOLE | 1566 - 9081 | 7515 | 8.75 | | | | | | | | |

**Response to Specific Comments, SC-26 (Cypress and Old Barberry Only)**

**Cypress M-2 Well Construction Procedures (Plug and Abandon) v4.pdf**

## 1.0 GENERAL WELL INFORMATION

| | |
|---|---|
| **Well Name** | Cypress M2 |
| **Well ID/API** | 49-021-29598 |
| **Field** | Wildcat |
| **Well Type** | Stratigraphic |
| **Ground Elevation** | 5224’ (Ungraded)’ |
| **State, County** | Wyoming, Laramie |
| **Proposed TD** | 9,081’ |
| **S-T-R** | Sec 14 – T13N – R61W |
| **Latitude, Longitude (NAD-83)** | 41.0862392°N, 104.1773538°W |
| **Formation** | Lyons/Amazon |
| **Perforations** | None |
| **Maximum Anticipated Pressure** | 3,080 psi |
| **Work Order/AFE Number** | 724-000037 |

## 2.0 OBJECTIVE

2.1 To safely plug and abandon this well after well construction is complete.

2.2 See Well Bore Diagram for casing details in Appendix 5.1

2.3 Drilling this well shall be planned and performed in accordance with guidelines defined by the State of Wyoming as well as the Tres Management Engineering Standard TSP 575-01-21.0 (1/14/2021).

2.4 Monitor worksite conditions to protect the environment and the safety and health of workers and the public. Safeguards will be used to prevent fluid run off of location.

## 3.0 CEMENTING REQUIREMENTS

3.1 Cement design will meet or exceed requirements of TSP 575-01-21.0, which must be verified by Lab Test conducted in accordance with API RP 10B2.

3.2 Communicate with Schlumberger Cement, the well bore geometry including pipe sizes, weights, depths, volumes, rates, pressures and any other pertinent information regarding the well. **SLB request a 6 Hour Callout Notification**.

3.3 Discuss with the cementing vendor the expectations of the cement mix, volumes of fresh water needed to complete the job including mix, displacement and cleanup water as well as other details that need to be followed during the cement job.

3.4 Cement Mixing Water Testing Requirements

| Parameter | Suggested Limits |
|---|---|
| pH | 5-9 |
| Specific Gravity | No Limits Suggested |
| Calcium | 1,000 mg/l Max |
| Chlorides | 10,000 mg/l Max |
| Carbonates | 2,000 mg/l Max |
| Sulfates | 10,000 mg/l Max |
| Tannins & Lignins (Sugars) | 250 mg/l Max |

3.5 Catch wet and dry samples of all cement slurries pumped. Weigh wet samples and record on the daily and cement reports. Retain samples will be held for 60 days after the rig has been released.

3.6 All lab test will be conducted with water acquired from same source as the cement job. Cement contractor will test water to ensure it's compatible with the additives in the cement to achieve the desired results. Record the pH and temperature of the mix water on the cement contractor's report. Ensure there is sufficient water on location before starting job to mix, displace and cleanup equipment.

3.7 Pressure test cementing lines to 85% of tubing Internal Yield Pressure against cementing head with valve closed. To pass test, the lines shall have no visible leaks or pressure falling off more than 10% during the 5 minute test. Cement lines must pass test prior to starting job.

3.8 Whilst pumping cement into wellbore, continuous monitoring of pump volumetric rate and pressure will be charted and reported. Losses or reductions in returns will be reported on the Tres Engineering Cement Report. At no time, will the pump pressure exceed test pressure.

## 4.0 PLUG AND ABANDONMENT

4.1 TIH with open ended 5" drillpipe.

4.2 TIH and tag bottom at 9086'.

4.3 Spot 12 BBL high-vis mud pill on bottom (+/- 150' in 8 ¾" Hole). POOH slowly to 8928'.

4.4 R/U cementers and spot 500' balanced cement plug #8 from 8928' – 8428'. Calculate cement volume based on 5% excess and 8 ¾" hole.

4.4.1 Pump 28.2 BBL Mudpush Spacer mixed at 12.0 ppg

4.4.2 Pump 38.6 BBL EverCRETE Cement mixed at 15.8 ppg

4.4.3 Pump 9.7 BBL Mudpush Spacer mixed at 12.0 ppg

4.4.4 Displace cement and spacers with 139.1 BBL OBM

4.4.5 Drop foam balls as plugs between spacer and cement stages.

4.5 POOH slowly (20-30'/min) to ~8100'. Circulate the hole clean.

4.6 WOC for at least 8.5 hours or the time it takes for cement to develop at least 500psi compressive strength.

4.7 TIH and tag plug top with at least 5k set down weight. If cement top is below planned depth of 8428', contact the office and discuss need for additional cement.

4.8 Once plug is tagged at 8428', Spot 9 BBL high-vis mud pill on bottom (+/- 117' in 8 ¾" Hole). POOH slowly to 8311'.

4.9 R/U cementers and spot 750' balanced cement plug #7 from 8311' – 7561'. Calculate cement volume based on 5% excess and 8 ¾" hole.

4.9.1 Pump 18.6 BBL Mudpush Spacer mixed at 12.0 ppg

4.9.2 Pump 56.9 BBL Class G Cement mixed at 15.8 ppg

4.9.3 Pump 6.4 BBL Mudpush Spacer mixed at 12.0 ppg

4.9.4 Displace cement and spacers with 126.7 BBL OBM

4.9.5 Drop foam balls as plugs between spacer and cement stages.

4.10 POOH slowly (20-30'/min) to ~7200'. Circulate the hole clean.

4.11 TIH to 7392'. Spot 19 BBL high-vis mud pill on bottom (+/- 250' in 8 ¾" Hole). POOH slowly to 6798'.

4.12 R/U cementers and spot 158' balanced cement plug #6 from 7142' – 6984'. Calculate cement volume based on 5% excess and 8 ¾" hole.

4.12.1 Pump 18.6 BBL Mudpush Spacer mixed at 12.0 ppg

4.12.2 Pump 11.9 BBL Class G Cement mixed at 15.8 ppg

4.12.3 Pump 6.4 BBL Mudpush Spacer mixed at 12.0 ppg

4.12.4 Displace cement and spacers with 117.4 BBL OBM

4.12.5 Drop foam balls as plugs between spacer and cement stages.

4.13 POOH slowly (20-30'/min) to ~6600'. Circulate the hole clean.

4.14 TIH to 6898'. Spot 12 BBL high-vis mud pill on bottom (+/- 150' in 8 ¾" Hole). POOH slowly to 5386'.

4.15 R/U cementers and spot 100' balanced cement plug #5 from 6748' – 6648'. Calculate cement volume based on 5% excess and 8 ¾" hole.

4.15.1 Pump 18.6 BBL Mudpush Spacer mixed at 12.0 ppg

4.15.2 Pump 7.6 BBL Class G Cement mixed at 15.8 ppg

4.15.3 Pump 6.4 BBL Mudpush Spacer mixed at 12.0 ppg

4.15.4 Displace cement and spacers with 11.6 BBL OBM

4.15.5 Drop foam balls as plugs between spacer and cement stages.

4.16 POOH slowly (20-30'/min) to ~6100'. Circulate the hole clean.

4.17 TIH to 5886'. Spot 38 BBL high-vis mud pill on bottom (+/- 500' in 8 ¾" Hole). POOH slowly to 5386'.

4.18 R/U cementers and spot 200' balanced cement plug #4 from 5386' – 5186'. Calculate cement volume based on 5% excess and 8 ¾" hole.

4.18.1 Pump 18.8 BBL Mudpush Spacer mixed at 12.0 ppg

4.18.2 Pump 15.5 BBL Class G Cement mixed at 15.8 ppg

4.18.3 Pump 6.2 BBL Mudpush Spacer mixed at 12.0 ppg

4.18.4 Displace cement and spacers with 85.5 BBL OBM

4.18.5 Drop foam balls as plugs between spacer and cement stages.

4.19 POOH slowly (20-30'/min) to ~4800'. Circulate the hole clean.

4.20 POOH to 4019'. Spot 38 BBL high-vis mud pill on bottom (+/- 500' in 8 ¾" Hole). POOH slowly to 3519'.

4.21 R/U cementers and spot 100' balanced cement plug #3 from 3519' – 3419'. Calculate cement volume based on 5% excess and 8 ¾" hole.

4.21.1 Pump 18.9 BBL Mudpush Spacer mixed at 12.0 ppg

4.21.2 Pump 7.9 BBL Class G Cement mixed at 15.8 ppg

4.21.3 Pump 6.1 BBL Mudpush Spacer mixed at 12.0 ppg

4.21.4 Displace cement and spacers with 54.4 BBL OBM

4.21.5 Drop foam balls as plugs between spacer and cement stages.

4.22 POOH slowly (20-30'/min) to ~3100'. Circulate the hole clean.

4.23 TIH to 2152'. Spot 38 BBL high-vis mud pill on bottom (+/- 500' in 8 ¾" Hole). POOH slowly to 1652'.

4.24 R/U cementers and spot 250' balanced cement plug #2 from 1652' – 1402'. Calculate cement volume based on 5% excess and 8 ¾" hole.

4.24.1 Pump 18.6 BBL Mudpush Spacer mixed at 12.0 ppg

4.24.2 Pump 20.6 BBL Class G Cement mixed at 15.8 ppg

4.24.3 Pump 6.4 BBL Mudpush Spacer mixed at 12.0 ppg

4.24.4 Displace cement and spacers with 18.1 BBL OBM

4.24.5 Drop foam balls as plugs between spacer and cement stages.

4.25 POOH slowly (20-30'/min) to ~1100'. Circulate the hole clean.

4.26 POOH to 700'. Spot 38 BBL high-vis mud pill on bottom (+/- 500' in 9 5/8" Cased Hole). POOH slowly to 200'.

4.27 *Spot 200' of neat Class G Cement* (Plug #1).

4.27.1 Pump 25 BBL Mudpush Spacer mixed at 12.0 ppg

4.27.2 Pump 15.2 BBL Class G Cement mixed at 15.8 ppg

4.28 *POOH and lay down drillpipe. Flush stack and wellhead to cut depth of 6' below ground level.*

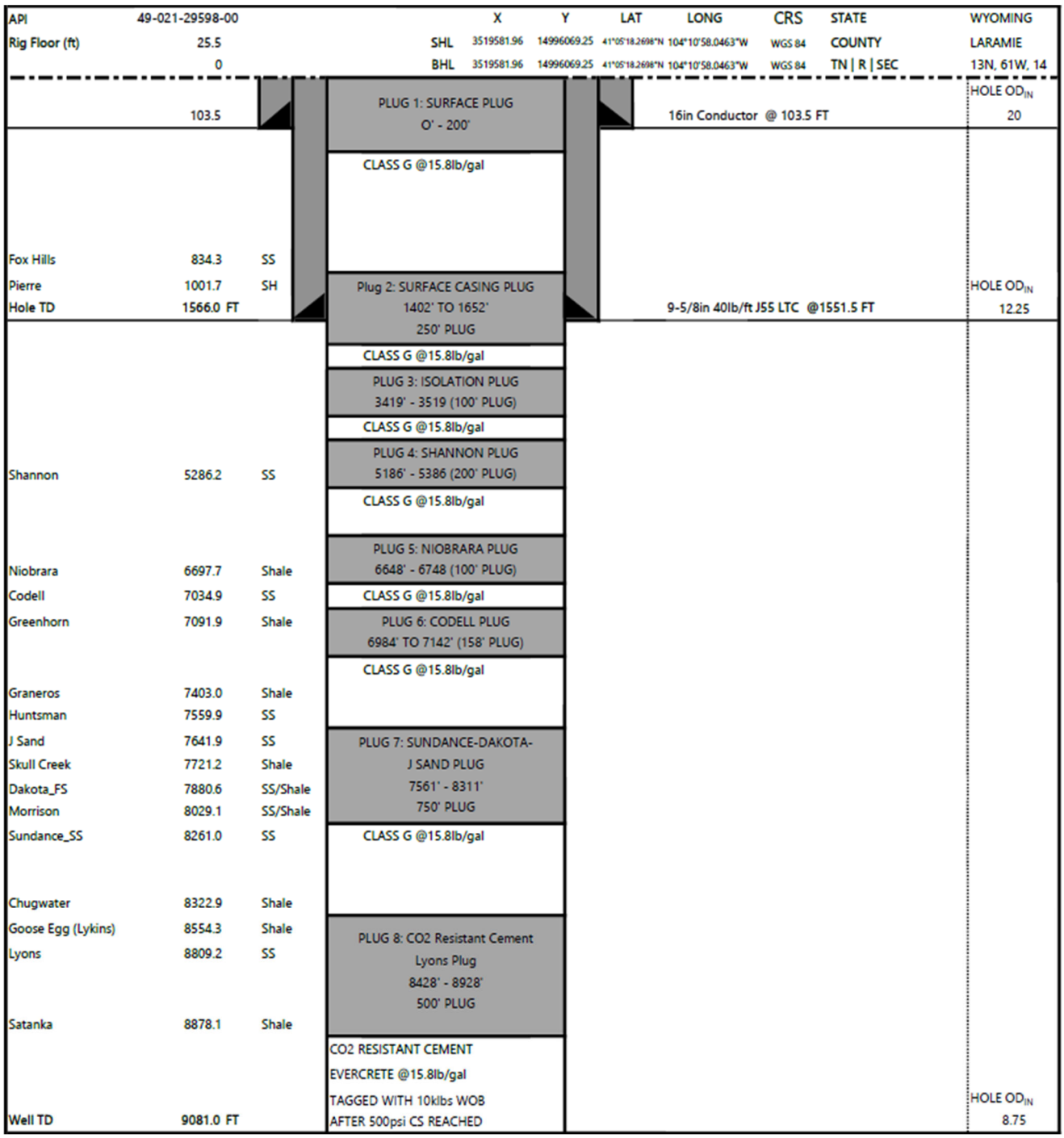
4.29 *Ensure the cement level does not fall.*

4.30 *N/D BOP & Wellhead. Cut casing 6' below ground level. Weld on plate with well name and API number stenciled on the top to complete abandonment.*

4.31 *RDMO True 38.*

## 5.0 APPENDICIES

### 5.1 Plugging Diagram



5.2 Contacts List

| Contacts | | |
|---|---|---|
| Drilling Engineer | John Prejean | 405-205-0771 |
| Project Lead | Luke Riggins | 405-264-3283 |
| Tallgrass Operations | Ricardo Mendez | 979-574-4363 |
| Tallgrass Land | Cody Wagoner | 970-301-2299 |
| Tallgrass Geologist | Trey Lyons | 281-785-6745 |
| Consultant Day | Shane Downs | 620-388-1518 |
| Consultant Night | Kevin Martin | 318-707-4032 |
| Safety Consultant | Philip Warren | 940-781-1517 |
| WOGCC | Main Phone No. | 307-234-7147 |
| True Drill Superintendent | Ray Daugherty | 307-215-4644 |
| True Drill Safety | Brian Blosmo | 307-258-9500 |
| Downing | Bo Adkisson | 307-337-7606 |
| Baroid | Chad Lackey | 405-985-9610 |
| SLB Cement | Central Dispatch | 701-314-2327 |

**Response to Specific Comments, SC-26 (Cypress and Old Barberry Only)**

**SLB Procedure, Treatment and Lab Reports – All Plugs**

# WCO 2023-158 – Tallgrass Energy – True Drilling #38 – CYPRESS M-2 - Plug #1 – PlugToAbandon – 15.8 ppg - Plug #1 - Lab Report

| | | | |
|---|---|---|---|
| Jan-24-2024 | Casing: 5 | District: Windsor, CO | Design Input By: Sol Maldonado-Aviles |
| BHCT / BHST | 80 / 65 °F | BHP: 500 psi | MD / TVD: 200.00 / 200.00 ft |

## Composition Pilot Version 1

| | | | | | |
|---|---|---|---|---|---|
| Slurry Density | 15.80 lb/gal | Yield | 1.16 ft³/sk of blend | Mix Fluid | 5.130 gal/sk SackOfBlend |
| Solid Vol. Fraction | 40.55 % | Slurry Type | Plug w/ Spacer | Mix Water | 5.110 gal/sk SackOfBlend |
| Blend Sack | 94.00 lb | Blend Density | 3.20 SG | | |

| Code | Concentration | Component | Lot Number |
|---|---|---|---|
| D907 | 100.00 % BWOB | Cement | BULK |
| S001 | 0.50 % BWOB | Accelerator | 364LD1042 |
| D047 | 0.020 gal/sk VBWOB | Anti Foam | 04182021 |
| Rig Water | 5.110 gal/sk of blend | Base Fluid | 1/11/24 |

| Surface Rheology | | | |
|---|---|---|---|
| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
| 300 | 49 | 49 | 49 |
| 200 | 41 | 41 | 41 |
| 100 | 31 | 31 | 31 |
| 60 | 24 | 26 | 25 |
| 30 | 20 | 22 | 21 |
| 6 | 13 | 17 | 15 |
| 3 | 11 | 14 | 12 |
| 10 sec Gel | 12 deg - 13 lbf/100ft² | | |
| 10 min Gel | 14 deg - 15 lbf/100ft² | | |
| Bingham $P_V$ | 35 cP | | |
| Bingham $T_y$ | 16 lbf/100ft² | | |
| Measured Temp | 80 °F | | |
| Viscometer I.D. | S/N 384 with R1B1 F1.0 | | |

| Downhole Rheology | | | |
|---|---|---|---|
| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
| 300 | 65 | 65 | 65 |
| 200 | 55 | 54 | 55 |
| 100 | 43 | 42 | 43 |
| 60 | 37 | 37 | 37 |
| 30 | 32 | 32 | 32 |
| 6 | 14 | 16 | 15 |
| 3 | 9 | 11 | 10 |
| 10 sec Gel | 10 deg - 11 lbf/100ft² | | |
| 10 min Gel | 18 deg - 19 lbf/100ft² | | |
| Bingham $P_V$ | 49 cP | | |
| Bingham $T_y$ | 20 lbf/100ft² | | |
| Measured Temp | 80 °F | | |
| Viscometer I.D. | S/N with 384 R1B1 F1.0 | | |

## Free Fluid

| |
|---|
| **0%** (0 mL / 250 mL) in 2 hrs at 61 °F and 0 deg inclination |
| Sedimentation: None |
| Test Method: Ambient |
| Cylinder Dimensions: 215x35 mm |

## Thickening Time Thickening Time 1

| Consistency | Time |
|---|---|
| KSQR TT | 02:17 to 03:17 hr:mn |
| POD | 02:00 hr:mn |
| 30 Bc | 03:51 hr:mn |
| 50 Bc | 05:05 hr:mn |
| 70 Bc | 05:55 hr:mn |
| Go/No-Go | Motor off at n/a for n/a |
| Consistometer S/N | 1359L |
| Set Conditions | SetHard |

## UCA Compressive Strength UCA 2: 100% cement

| Time | Compressive Strength | Acoustic Impedance |
|---|---|---|
| 03:00 hr:mn | 50 psi | 3.07 Mrayl |
| 08:49 hr:mn | 500 psi | 4.07 Mrayl |
| 12:00 hr:mn | 794 psi | 4.43 Mrayl |
| 24:00 hr:mn | 1607 psi | 5.08 Mrayl |
| Machine S/N: | 808L | |

## Comments

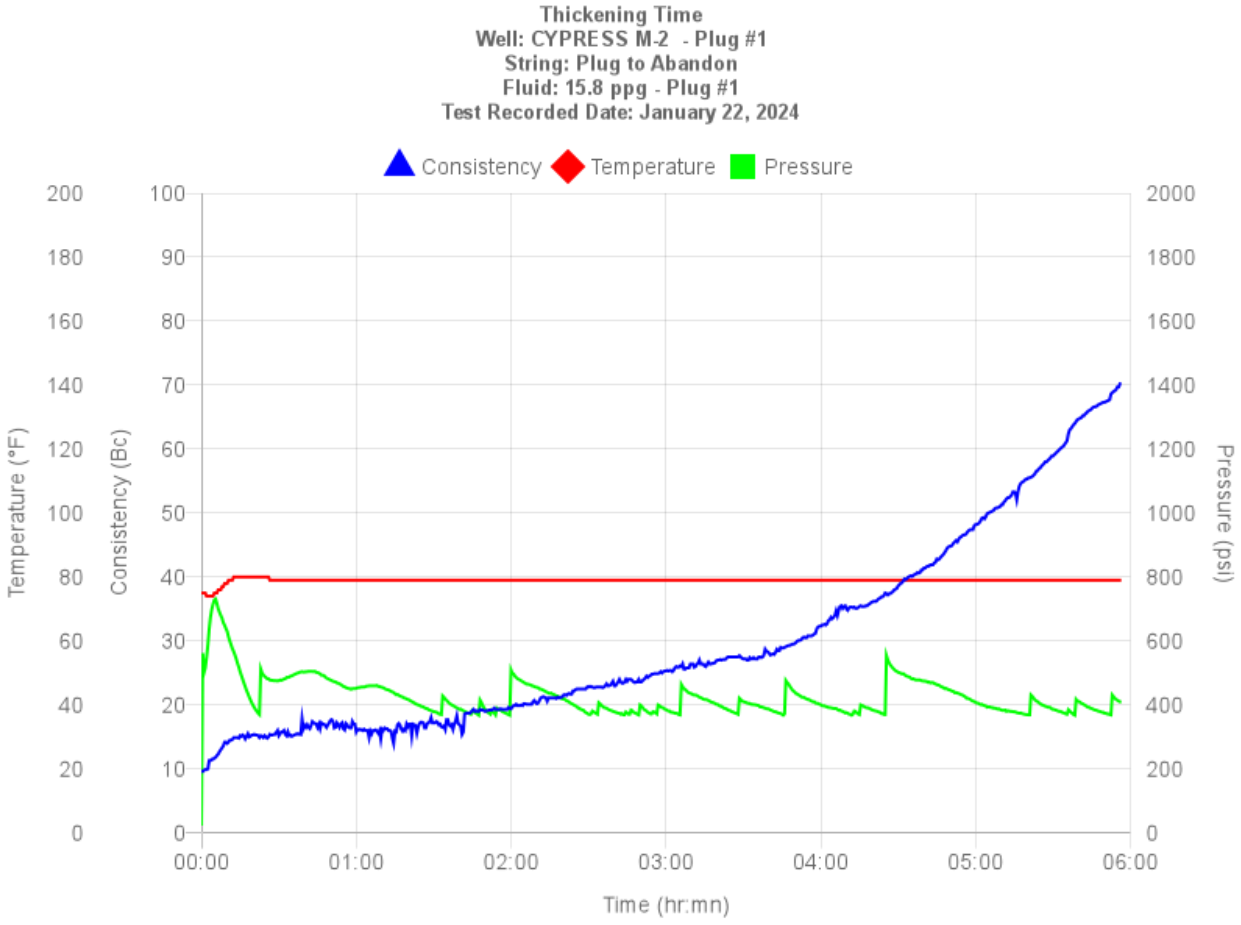
All slurries prepared and tested in accordance with SLB WIT Laboratory Standard Work Instructions.

Mixability assessment: **00:15 mn:sc** to add solids to blender. Vortex quality was **good/visible** after all solids added.
At time of lab testing base fluid temperature was **62 °F**, and blend temperature was **67 °F**

Water sample comment: Chloride content of water sample used for slurry testing was **<300** ppm

Synapse UID: **280770**

Liquid additives (if used) are added to the mix water in the following order prior to adding dry blend: Gas migration additive is injected to the water in the blender first at 4000rpm; then anti-foam; followed last by other liquids.



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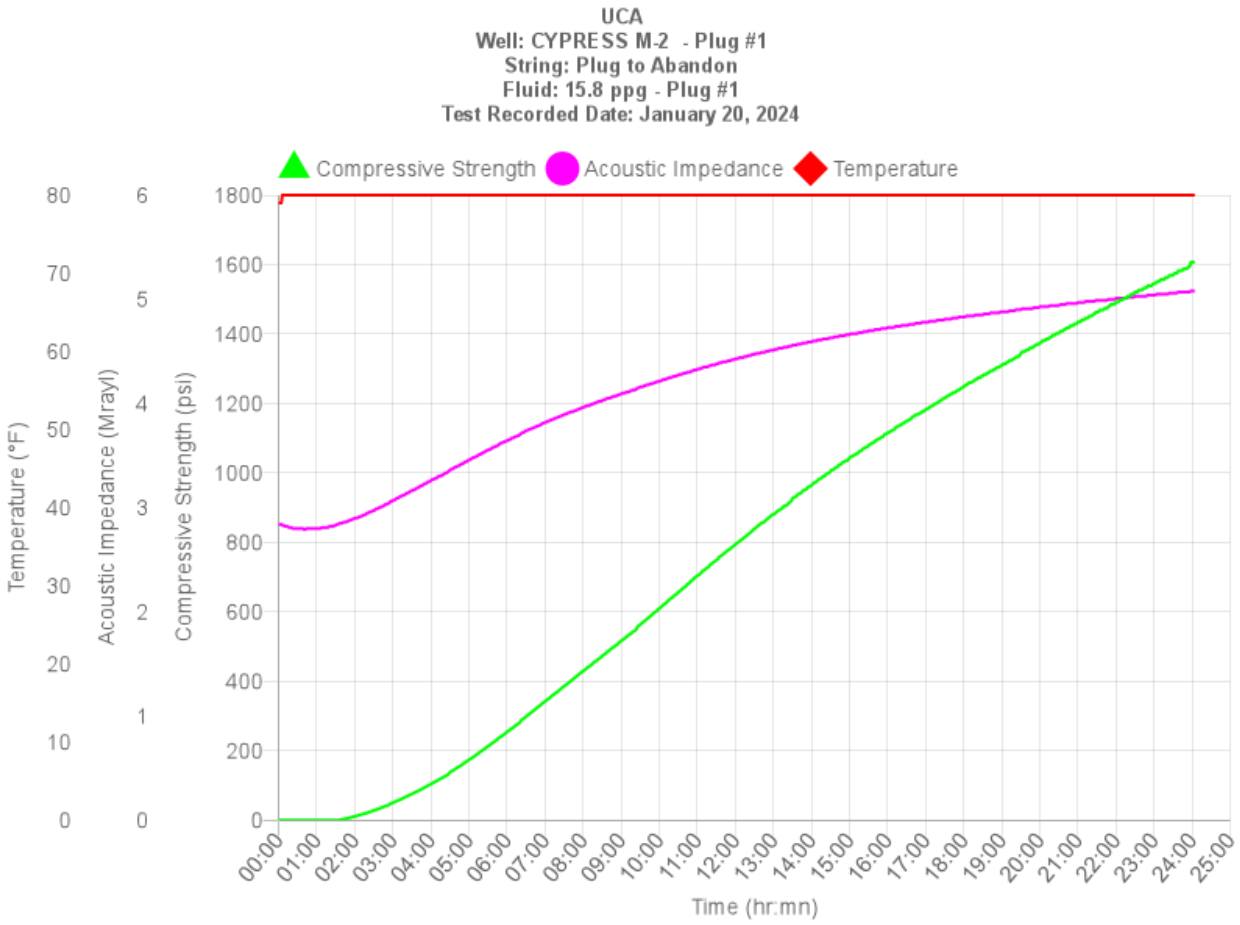





Schlumberger-Private

# WCO 2024-16 – Tallgrass Energy – True Drilling #38 – CYPRESS M-2 Plug #2 – PlugToAbandon – 15.8 ppg - Plug #2 - Lab Report

| | | | |
|---|---|---|---|
| Jan-24-2024 | Casing: 5 | District: Windsor, CO | Design Input By: Andrew Barros |
| BHCT / BHST | 80 / 90 °F | BHP: 1,000 psi | MD / TVD: 1,651.50 / 1,651.50 ft |

## Composition Pilot Version 1

| | | | | | |
|---|---|---|---|---|---|
| Slurry Density | 15.80 lb/gal | Yield | 1.16 ft³/sk of blend | Mix Fluid | 5.132 gal/sk SackOfBlend |
| Solid Vol. Fraction | 40.68 % | Slurry Type | Plug w/ Spacer | Mix Water | 5.112 gal/sk SackOfBlend |
| Blend Sack | 94.00 lb | Blend Density | 3.20 SG | | |

| Code | Concentration | Component | Lot Number |
|---|---|---|---|
| D907 | 100.00 % BWOB | Cement | BULK |
| D047 | 0.020 gal/sk VBWOB | Anti Foam | 04182021 |
| Rig Water | 5.112 gal/sk of blend | Base Fluid | 1/11/24 |

| Surface Rheology | | | |
|---|---|---|---|
| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
| 300 | 47 | 47 | 47 |
| 200 | 39 | 38 | 39 |
| 100 | 29 | 29 | 29 |
| 60 | 24 | 25 | 25 |
| 30 | 20 | 21 | 21 |
| 6 | 11 | 14 | 12 |
| 3 | 8 | 13 | 11 |
| 10 sec Gel | 11 deg - 12 lbf/100ft² | | |
| 10 min Gel | 13 deg - 14 lbf/100ft² | | |
| Bingham $P_V$ | 35 cP | | |
| Bingham $T_y$ | 15 lbf/100ft² | | |
| Measured Temp | 80 °F | | |
| Viscometer I.D. | S/N 384 with R1B1 F1.0 | | |

| Downhole Rheology | | | |
|---|---|---|---|
| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
| 300 | 46 | 46 | 46 |
| 200 | 38 | 38 | 38 |
| 100 | 31 | 31 | 31 |
| 60 | 26 | 26 | 26 |
| 30 | 22 | 23 | 23 |
| 6 | 14 | 16 | 15 |
| 3 | 8 | 10 | 9 |
| 10 sec Gel | 10 deg - 11 lbf/100ft² | | |
| 10 min Gel | 14 deg - 15 lbf/100ft² | | |
| Bingham $P_V$ | 32 cP | | |
| Bingham $T_y$ | 16 lbf/100ft² | | |
| Measured Temp | 80 °F | | |
| Viscometer I.D. | S/N with 384 R1B1 F1.0 | | |

## Free Fluid

| |
|---|
| **0%** (0 mL / 250 mL) in 2 hrs at 66 °F and 0 deg inclination |
| Sedimentation: None |
| Test Method: Ambient |
| Cylinder Dimensions: 215x35 mm |

## Thickening Time Thickening Time 1

| Consistency | Time |
|---|---|
| KSQR TT | 02:50 to 03:50 hr:mn |
| POD | 01:51 hr:mn |
| 30 Bc | 02:11 hr:mn |
| 50 Bc | 03:59 hr:mn |
| 70 Bc | 05:02 hr:mn |
| Go/No-Go | Motor off at 00:20 for 00:28 |
| Consistometer S/N | 1359R |
| Set Conditions | None |

## UCA Compressive Strength UCA 2: 100% cement

| Time | Compressive Strength | Acoustic Impedance |
|---|---|---|
| 03:34 hr:mn | 50 psi | 3.11 Mrayl |
| 09:05 hr:mn | 500 psi | 4.08 Mrayl |
| 12:00 hr:mn | 816 psi | 4.46 Mrayl |
| 24:00 hr:mn | 1957 psi | 5.30 Mrayl |
| Machine S/N: | value | |

## Comments

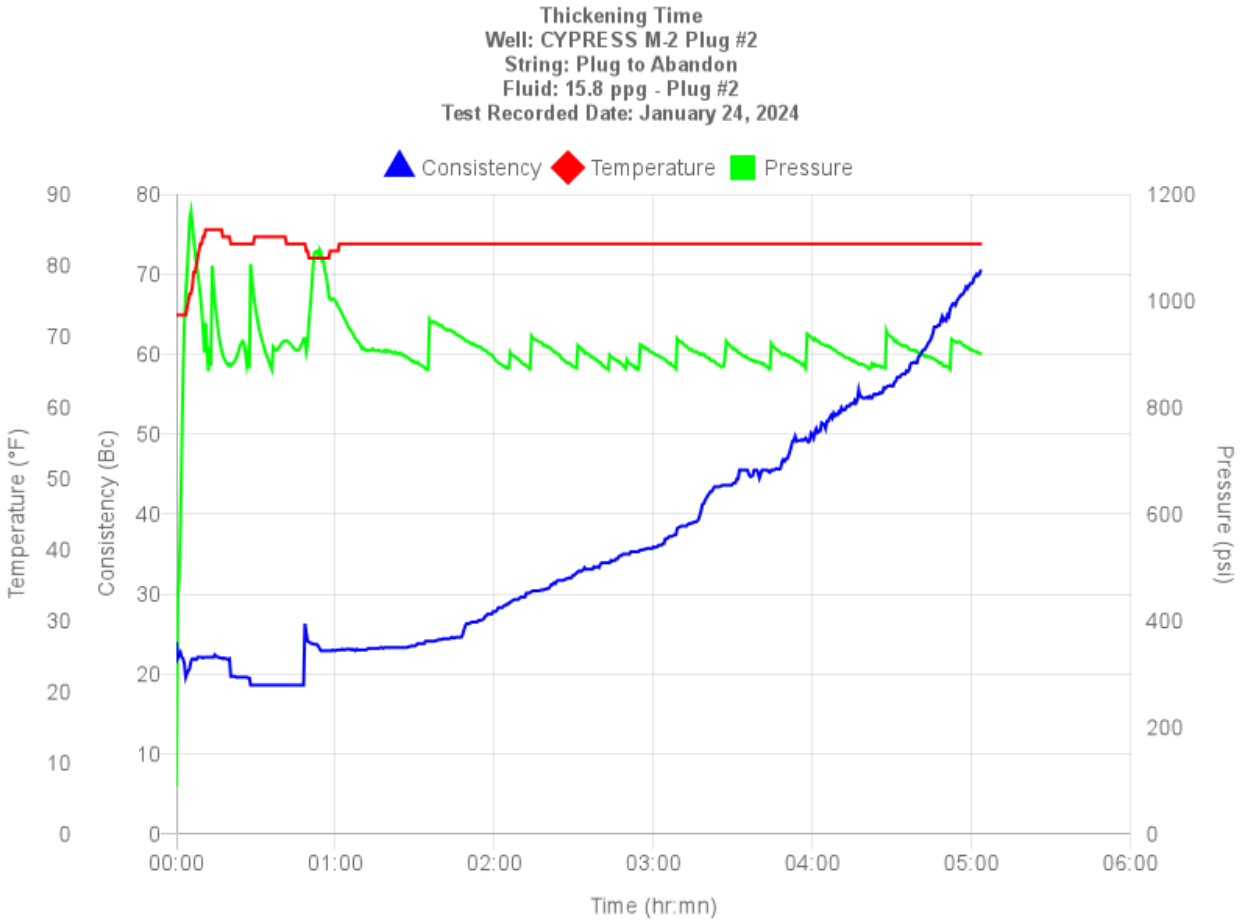
All slurries prepared and tested in accordance with SLB WIT Laboratory Standard Work Instructions.

Mixability assessment: **00:15 mn:sc** to add solids to blender. Vortex quality was **good/visible** after all solids added.
At time of lab testing base fluid temperature was **63 °F**, and blend temperature was **67 °F**

Water sample comment: Chloride content of water sample used for slurry testing was **<300** ppm

Synapse UID: **280550**

Liquid additives (if used) are added to the mix water in the following order prior to adding dry blend: Gas migration additive is injected to the water in the blender first at 4000rpm; then anti-foam; followed last by other liquids.



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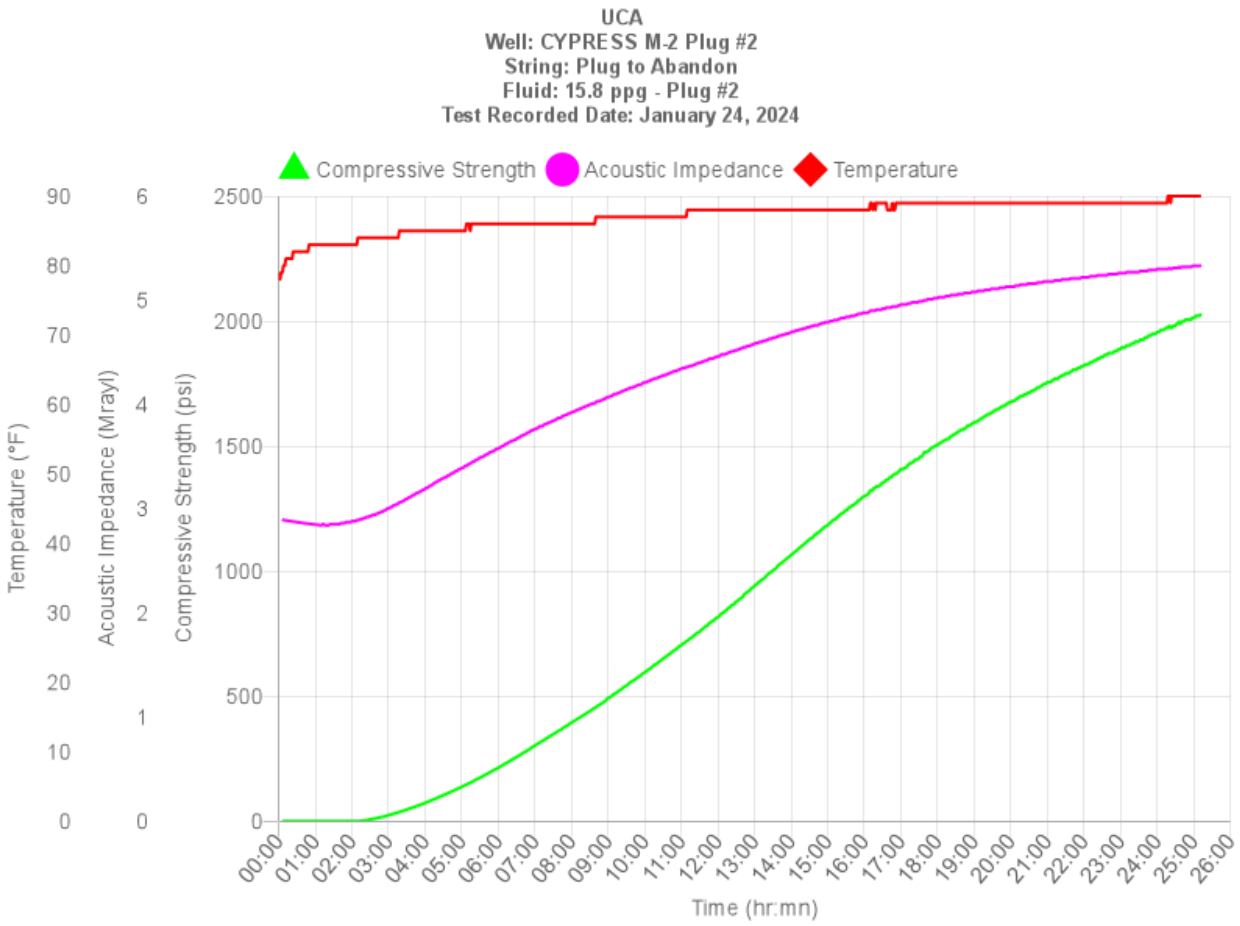





Schlumberger-Private

# WCO 2024-20 – Tallgrass Energy – True Drilling #38 – CYPRESS M-2 - Plug #3 – PlugToAbandon – 15.8 ppg - Plug #3 - Lab Report

| | | | |
|---|---|---|---|
| Jan-24-2024 | Casing: 5 | District: Windsor, CO | Design Input By: Andrew Barros |
| BHCT / BHST | 93 / 124 °F | BHP: 1,800 psi | MD / TVD: 3,519.00 / 3,519.00 ft |

## Composition Pilot Version 2

| | | | | | |
|---|---|---|---|---|---|
| Slurry Density | 15.80 lb/gal | Yield | 1.16 ft³/sk of blend | Mix Fluid | 5.147 gal/sk SackOfBlend |
| Solid Vol. Fraction | 40.61 % | Slurry Type | Plug w/ Spacer | Mix Water | 5.067 gal/sk SackOfBlend |
| Blend Sack | 94.00 lb | Blend Density | 3.20 SG | | |

| Code | Concentration | Component | Lot Number |
|---|---|---|---|
| D907 | 100.00 % BWOB | Cement | BULK |
| D080 | 0.050 gal/sk VBWOB | Dispersant | 8R3B0011E0 |
| D047 | 0.020 gal/sk VBWOB | Anti Foam | 04182021 |
| D801 | 0.010 gal/sk VBWOB | Retarder | 07R-11 |
| Rig Water | 5.067 gal/sk of blend | Base Fluid | 1/11/24 |

| Downhole Rheology | | | |
|---|---|---|---|
| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
| 300 | 44 | 44 | 44 |
| 200 | 36 | 36 | 36 |
| 100 | 29 | 29 | 29 |
| 60 | 24 | 24 | 24 |
| 30 | 20 | 21 | 21 |
| 6 | 12 | 14 | 13 |
| 3 | 8 | 10 | 9 |
| 10 sec Gel | 10 deg - 11 lbf/100ft² | | |
| 10 min Gel | 13 deg - 14 lbf/100ft² | | |
| Bingham $P_V$ | 32 cP | | |
| Bingham $T_y$ | 15 lbf/100ft² | | |
| Measured Temp | 93 °F | | |
| Viscometer I.D. | S/N 384 with R1B1 F1.0 | | |

| Surface Rheology | | | |
|---|---|---|---|
| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
| 300 | 45 | 45 | 45 |
| 200 | 37 | 36 | 37 |
| 100 | 27 | 27 | 27 |
| 60 | 22 | 23 | 23 |
| 30 | 18 | 19 | 19 |
| 6 | 10 | 12 | 11 |
| 3 | 8 | 11 | 10 |
| 10 sec Gel | 10 deg - 11 lbf/100ft² | | |
| 10 min Gel | 12 deg - 13 lbf/100ft² | | |
| Bingham $P_V$ | 34 cP | | |
| Bingham $T_y$ | 13 lbf/100ft² | | |
| Measured Temp | 80 °F | | |
| Viscometer I.D. | S/N with 384 R1B1 F1.0 | | |

## Free Fluid

| |
|---|
| **0%** (0 mL / 250 mL) in 2 hrs at 62 °F and 0 deg inclination |
| Sedimentation: None |
| Test Method: Ambient |
| Cylinder Dimensions: 215x35 mm |

## UCA Compressive Strength UCA 2: 100% cement

| Time | Compressive Strength | Acoustic Impedance |
|---|---|---|
| 02:00 hr:mn | 50 psi | 2.88 Mrayl |
| 04:07 hr:mn | 500 psi | 3.81 Mrayl |
| 12:00 hr:mn | 1800 psi | 4.87 Mrayl |
| 24:00 hr:mn | 2404 psi | 5.17 Mrayl |
| Machine S/N: | 808R | |

## Thickening Time Thickening Time 1

| Consistency | Time |
|---|---|
| KSQR TT | 03:08 to 04:08 hr:mn |
| POD | 02:08 hr:mn |
| 30 Bc | 02:29 hr:mn |
| 50 Bc | 03:14 hr:mn |
| 70 Bc | 03:42 hr:mn |
| Go/No-Go | Motor off at n/a for n/a |
| Consistometer S/N | 1359L |
| Set Conditions | SetHard |

## Comments

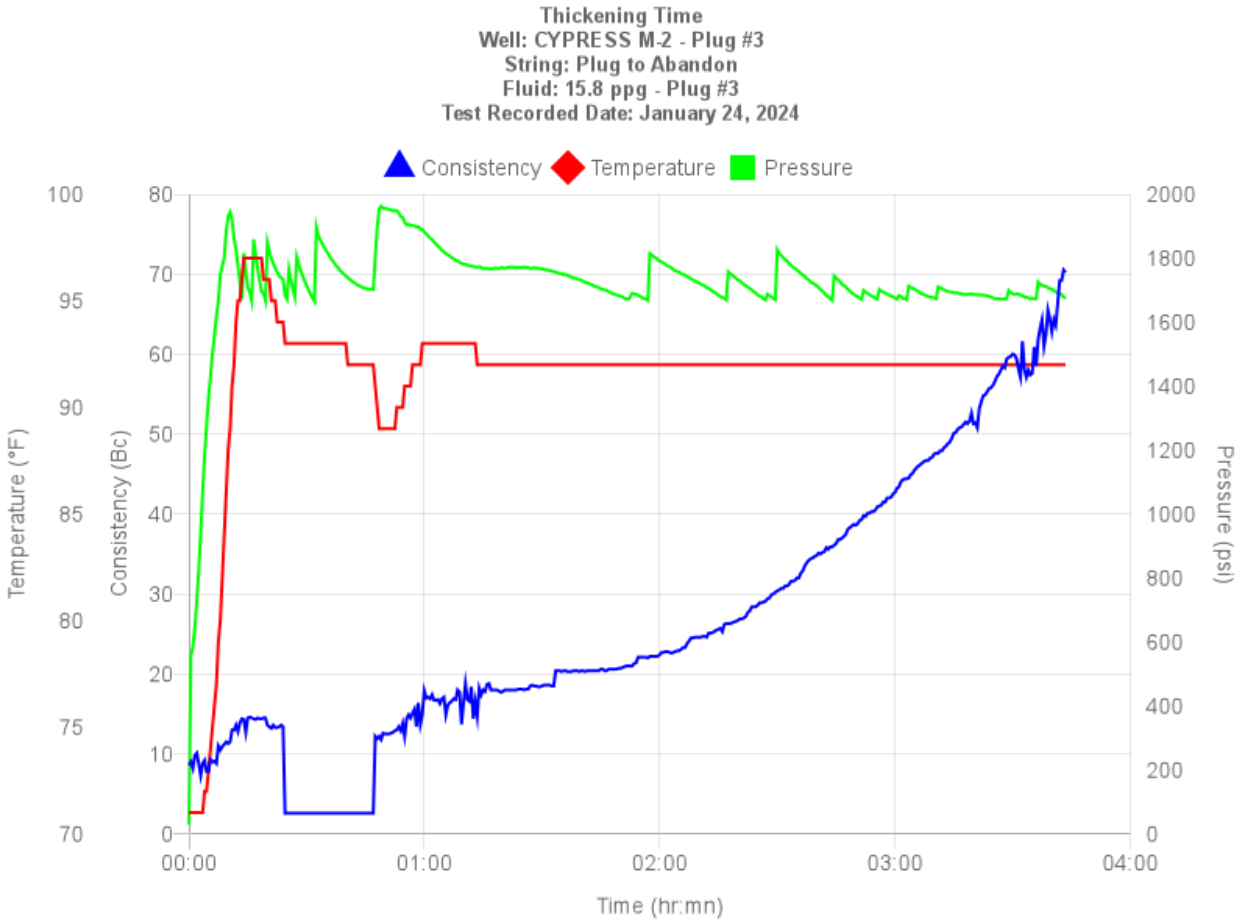
All slurries prepared and tested in accordance with SLB WIT Laboratory Standard Work Instructions.

Mixability assessment: **00:14 mn:sc** to add solids to blender. Vortex quality was **good/visible** after all solids added.
At time of lab testing base fluid temperature was **60 °F**, and blend temperature was **65 °F**

Water sample comment: Chloride content of water sample used for slurry testing was **<300** ppm

Synapse UID: **280559**

Liquid additives (if used) are added to the mix water in the following order prior to adding dry blend: Gas migration additive is injected to the water in the blender first at 4000rpm; then anti-foam; followed last by other liquids.



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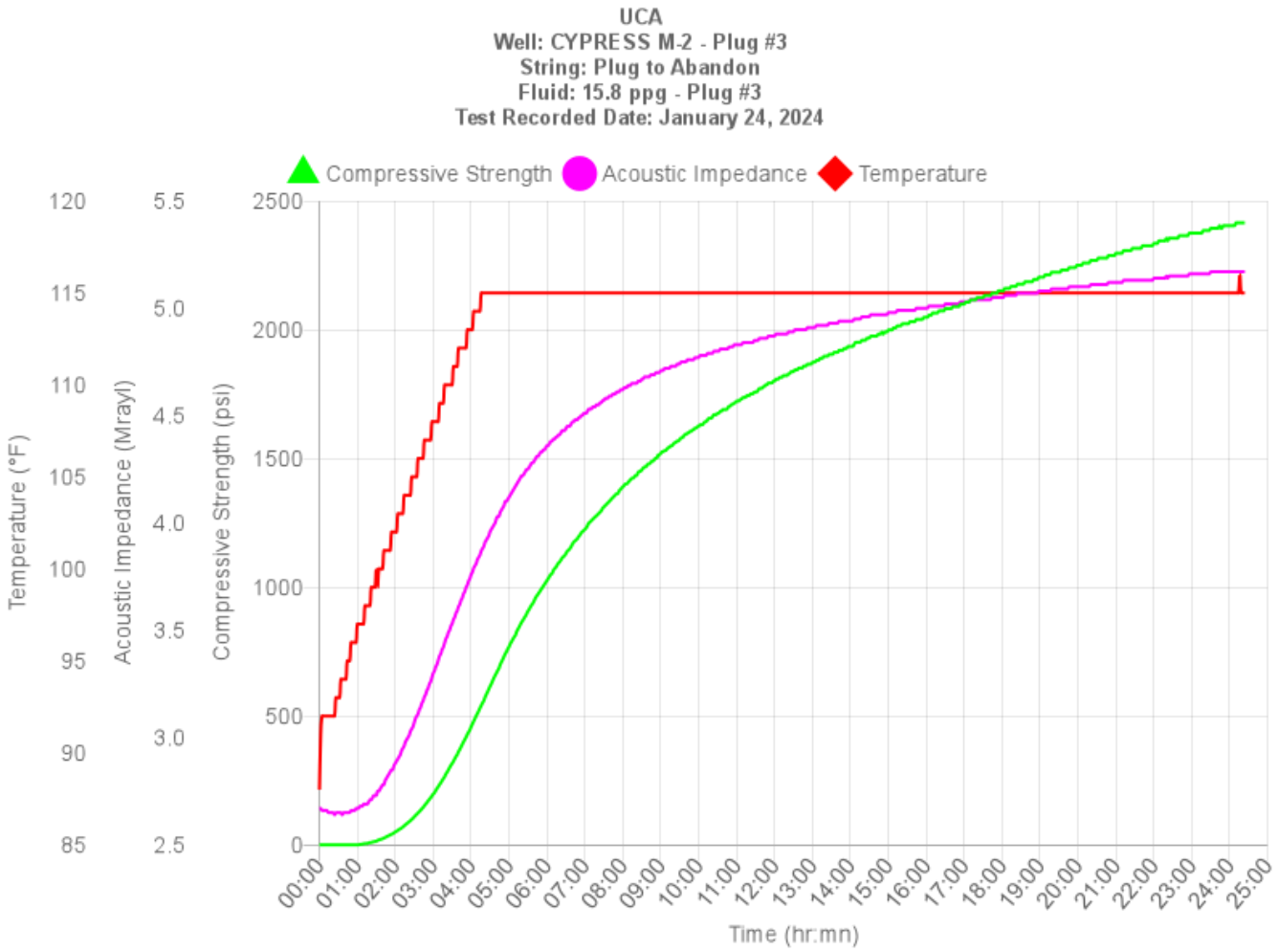




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# WCO 2023-156 – Tallgrass Energy – True Drilling #38 – CYPRESS M-2 - Plug #4 – PlugToAbandon – 15.8 ppg - Plug #4 - Lab Report

| | | | |
|---|---|---|---|
| Jan-25-2024 | Casing: 5 | District: Windsor, CO | Design Input By: Sol Maldonado-Aviles |
| BHCT / BHST | 117 / 157 °F | BHP: 2,800 psi | MD / TVD: 5,386.00 / 5,386.00 ft |

## Composition Pilot Version 3

| | | | | | |
|---|---|---|---|---|---|
| Slurry Density | 15.80 lb/gal | Yield | 1.16 ft³/sk of blend | Mix Fluid | 5.163 gal/sk SackOfBlend |
| Solid Vol. Fraction | 40.63 % | Slurry Type | Plug w/ Spacer | Mix Water | 5.053 gal/sk SackOfBlend |
| Blend Sack | 94.00 lb | Blend Density | 3.20 SG | | |

| Code | Concentration | Component | Lot Number |
|---|---|---|---|
| D907 | 100.00 % BWOB | Cement | BULK |
| D801 | 0.040 gal/sk VBWOB | Retarder | 07R-11 |
| D080 | 0.050 gal/sk VBWOB | Dispersant | 8R3B0011E0 |
| D047 | 0.020 gal/sk VBWOB | Anti Foam | 04182021 |
| D153 | 0.30 % BWOB | Anti-Settling Agent | 9T26M23D-6 |
| Rig Water | 5.053 gal/sk of blend | Base Fluid | 1/11/24 |

**Surface Rheology**

| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
|---|---|---|---|
| 300 | 60 | 60 | 60 |
| 200 | 43 | 43 | 43 |
| 100 | 26 | 26 | 26 |
| 60 | 19 | 18 | 19 |
| 30 | 14 | 13 | 14 |
| 6 | 9 | 5 | 7 |
| 3 | 6 | 5 | 6 |
| 10 sec Gel | 14 deg - 15 lbf/100ft² | | |
| 10 min Gel | 57 deg - 61 lbf/100ft² | | |
| Bingham $P_V$ | 54 cP | | |
| Bingham $T_y$ | 7 lbf/100ft² | | |
| Measured Temp | 80 °F | | |
| Viscometer I.D. | S/N 384 with R1B1 F1.0 | | |

**Downhole Rheology**

| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
|---|---|---|---|
| 300 | 66 | 66 | 66 |
| 200 | 50 | 48 | 49 |
| 100 | 31 | 30 | 31 |
| 60 | 25 | 23 | 24 |
| 30 | 20 | 17 | 19 |
| 6 | 15 | 10 | 13 |
| 3 | 11 | 8 | 10 |
| 10 sec Gel | 14 deg - 15 lbf/100ft² | | |
| 10 min Gel | 43 deg - 46 lbf/100ft² | | |
| Bingham $P_V$ | 55 cP | | |
| Bingham $T_y$ | 12 lbf/100ft² | | |
| Measured Temp | 117 °F | | |
| Viscometer I.D. | S/N with 384 R1B1 F1.0 | | |

## Free Fluid

| |
|---|
| **0%** (0 mL / 250 mL) in 2 hrs at 63 °F and 0 deg inclination |
| Sedimentation: None |
| Test Method: Ambient |
| Cylinder Dimensions: 215x35 mm |

## Thickening Time Thickening Time 1

| Consistency | Time |
|---|---|
| KSQR TT | 03:32 to 04:32 hr:mn |
| POD | 03:44 hr:mn |
| 30 Bc | 03:32 hr:mn |
| 50 Bc | 04:34 hr:mn |
| 70 Bc | 04:45 hr:mn |
| Go/No-Go | Motor off at 00:32 for 00:27 |
| Consistometer S/N | 754 |
| Set Conditions | SetHard |

## UCA Compressive Strength UCA 2: 100% cement

| Time | Compressive Strength | Acoustic Impedance |
|---|---|---|
| 03:23 hr:mn | 50 psi | 3.22 Mrayl |
| 04:12 hr:mn | 500 psi | 4.13 Mrayl |
| 00:00 hr:mn | 0 psi | 0.00 Mrayl |
| 00:00 hr:mn | 0 psi | 0.00 Mrayl |
| Machine S/N: | 808L | |

## Comments

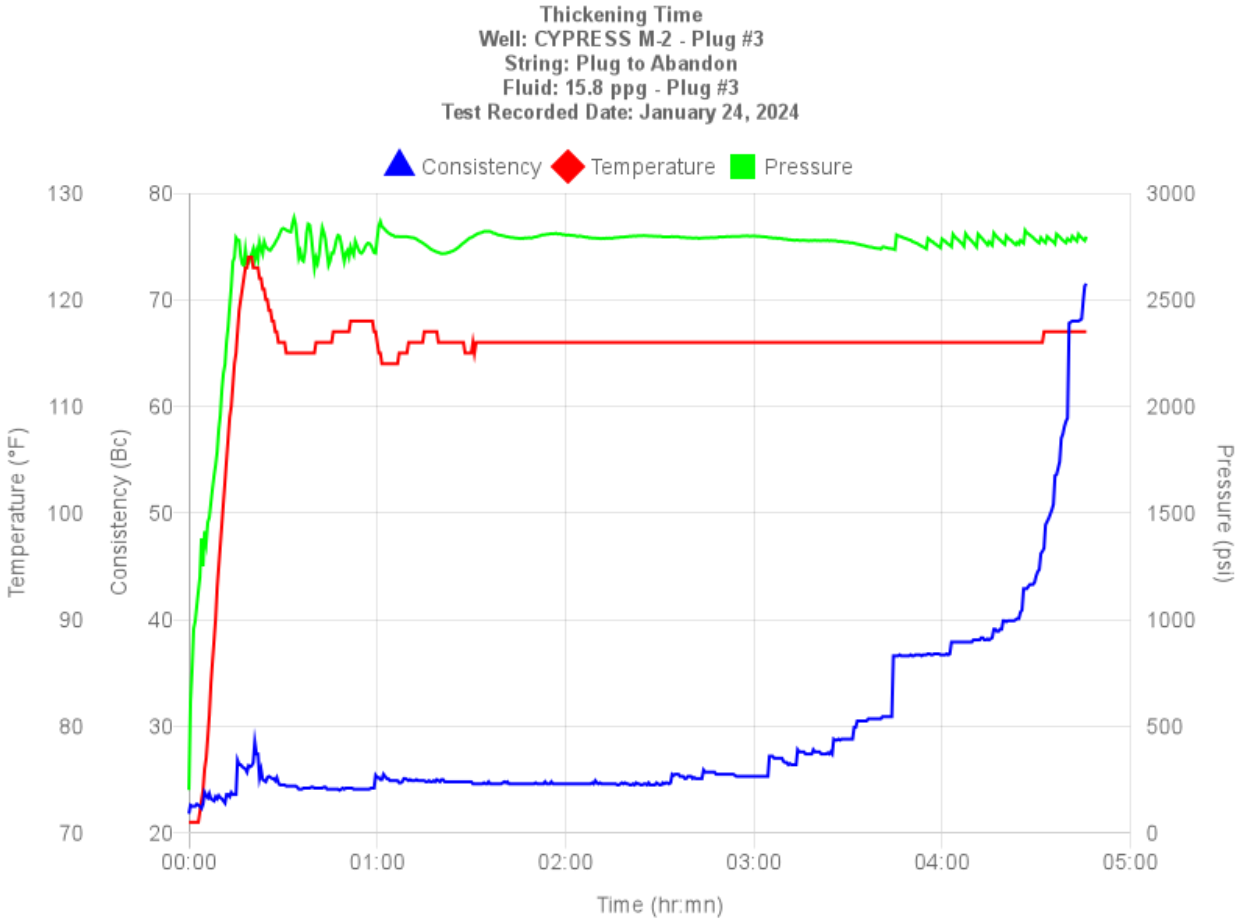
All slurries prepared and tested in accordance with SLB WIT Laboratory Standard Work Instructions.

Mixability assessment: **00:15 mn:sc** to add solids to blender. Vortex quality was **good/visible** after all solids added.
At time of lab testing base fluid temperature was **61 °F**, and blend temperature was **53 °F**

Water sample comment: Chloride content of water sample used for slurry testing was **<300** ppm

Synapse UID: **280615**

Liquid additives (if used) are added to the mix water in the following order prior to adding dry blend: Gas migration additive is injected to the water in the blender first at 4000rpm; then anti-foam; followed last by other liquids.



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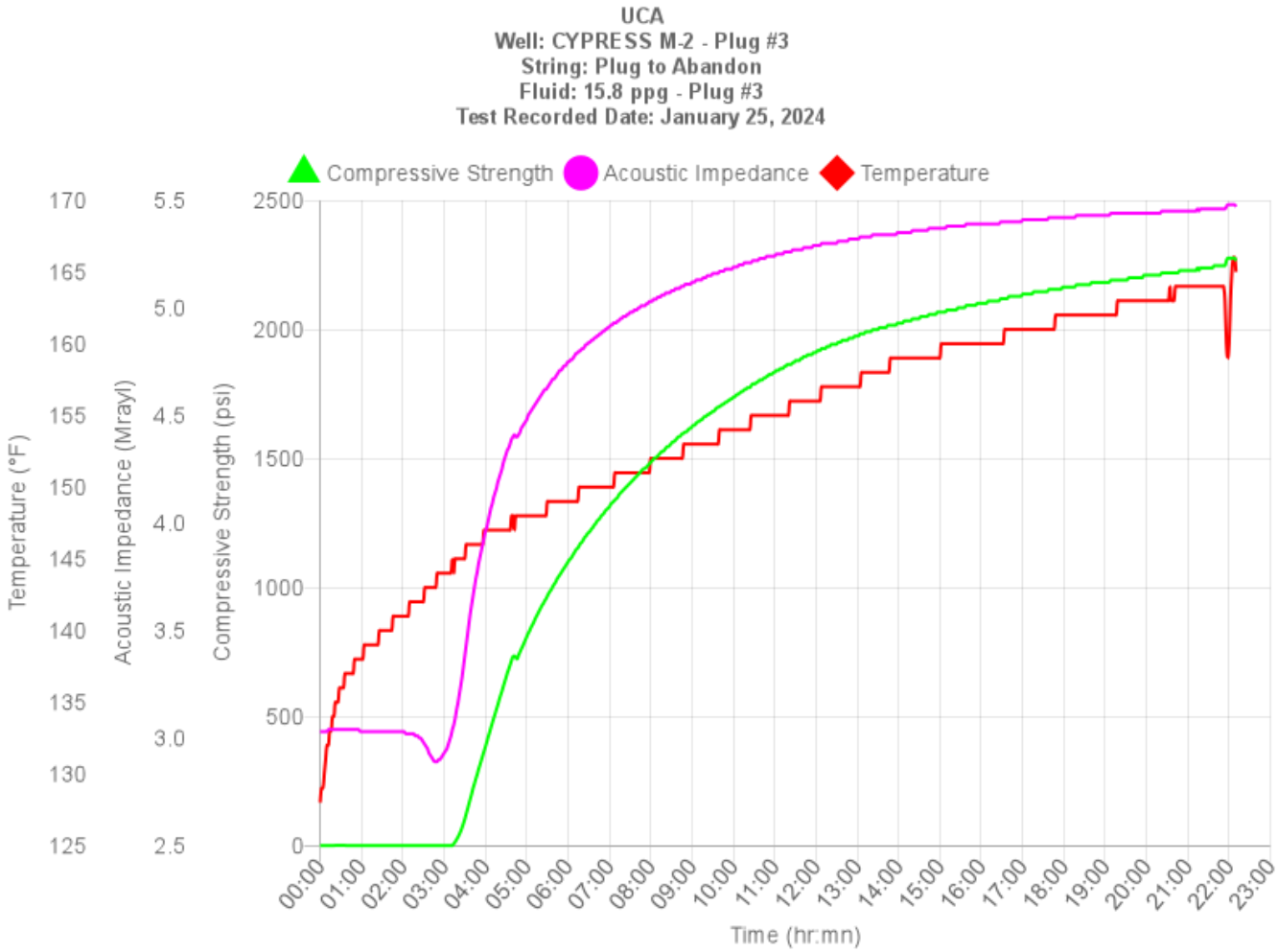





Schlumberger-Private

# WCO 2023-155 – Tallgrass Energy – True Drilling #38 – CYPRESS M-2 - Plug #5 – PlugToAbandon – 15.8 ppg - Plug #5 - Lab Report

| | | | |
|---|---|---|---|
| Jan-25-2024 | Casing: 5 | District: Windsor, CO | Design Input By: Sol Maldonado-Aviles |
| BHCT / BHST | 135 / 182 °F | BHP: 3,400 psi | MD / TVD: 6,748.00 / 6,748.00 ft |

## Composition Pilot Version 1

| | | | | | |
|---|---|---|---|---|---|
| Slurry Density | 15.80 lb/gal | Yield | 1.16 ft³/sk of blend | Mix Fluid | 5.163 gal/sk SackOfBlend |
| Solid Vol. Fraction | 40.63 % | Slurry Type | Plug w/ Spacer | Mix Water | 5.053 gal/sk SackOfBlend |
| Blend Sack | 94.00 lb | Blend Density | 3.20 SG | | |

| Code | Concentration | Component | Lot Number |
|---|---|---|---|
| D907 | 100.00 % BWOB | Cement | BULK |
| D801 | 0.040 gal/sk VBWOB | Retarder | 07R-11 |
| D080 | 0.050 gal/sk VBWOB | Dispersant | 8R3B0011E0 |
| D047 | 0.020 gal/sk VBWOB | Anti Foam | 04182021 |
| D153 | 0.30 % BWOB | Anti-Settling Agent | 9T26M23D-6 |
| Fresh Water | 5.053 gal/sk of blend | Base Fluid | 1/11/24 |

**Surface Rheology**

| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
|---|---|---|---|
| 300 | 60 | 60 | 60 |
| 200 | 43 | 43 | 43 |
| 100 | 26 | 26 | 26 |
| 60 | 19 | 18 | 19 |
| 30 | 14 | 13 | 14 |
| 6 | 9 | 5 | 7 |
| 3 | 6 | 5 | 6 |
| 10 sec Gel | 14 deg - 15 lbf/100ft² | | |
| 10 min Gel | 57 deg - 61 lbf/100ft² | | |
| Bingham $P_V$ | 54 cP | | |
| Bingham $T_y$ | 7 lbf/100ft² | | |
| Measured Temp | 80 °F | | |
| Viscometer I.D. | S/N 384 with R1B1 F1.0 | | |

**Downhole Rheology**

| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
|---|---|---|---|
| 300 | 66 | 66 | 66 |
| 200 | 50 | 48 | 49 |
| 100 | 31 | 30 | 31 |
| 60 | 25 | 23 | 24 |
| 30 | 20 | 17 | 19 |
| 6 | 15 | 10 | 13 |
| 3 | 11 | 8 | 10 |
| 10 sec Gel | 14 deg - 15 lbf/100ft² | | |
| 10 min Gel | 43 deg - 46 lbf/100ft² | | |
| Bingham $P_V$ | 55 cP | | |
| Bingham $T_y$ | 12 lbf/100ft² | | |
| Measured Temp | 137 °F | | |
| Viscometer I.D. | S/N with value R1B1 F1.0 | | |

## Free Fluid

| |
|---|
| **0%** (0 mL / 250 mL) in 2 hrs at 67 °F and 0 deg inclination |
| Sedimentation: None |
| Test Method: Ambient |
| Cylinder Dimensions: 215x35 mm |

## Thickening Time Thickening Time 1

| Consistency | Time |
|---|---|
| KSQR TT | 03:40 to 04:40 hr:mn |
| POD | 02:58 hr:mn |
| 30 Bc | 03:11 hr:mn |
| 50 Bc | 03:39 hr:mn |
| 70 Bc | 03:48 hr:mn |
| Go/No-Go | Motor off at 00:37 for 00:27 |
| Consistometer S/N | 1359L |
| Set Conditions | SetHard |

## UCA Compressive Strength UCA 2: 100% cement

| Time | Compressive Strength | Acoustic Impedance |
|---|---|---|
| 03:23 hr:mn | 50 psi | 3.22 Mrayl |
| 04:12 hr:mn | 500 psi | 4.13 Mrayl |
| 00:00 hr:mn | 0 psi | 0.00 Mrayl |
| 00:00 hr:mn | 0 psi | 0.00 Mrayl |
| Machine S/N: | 808L | |

## Comments

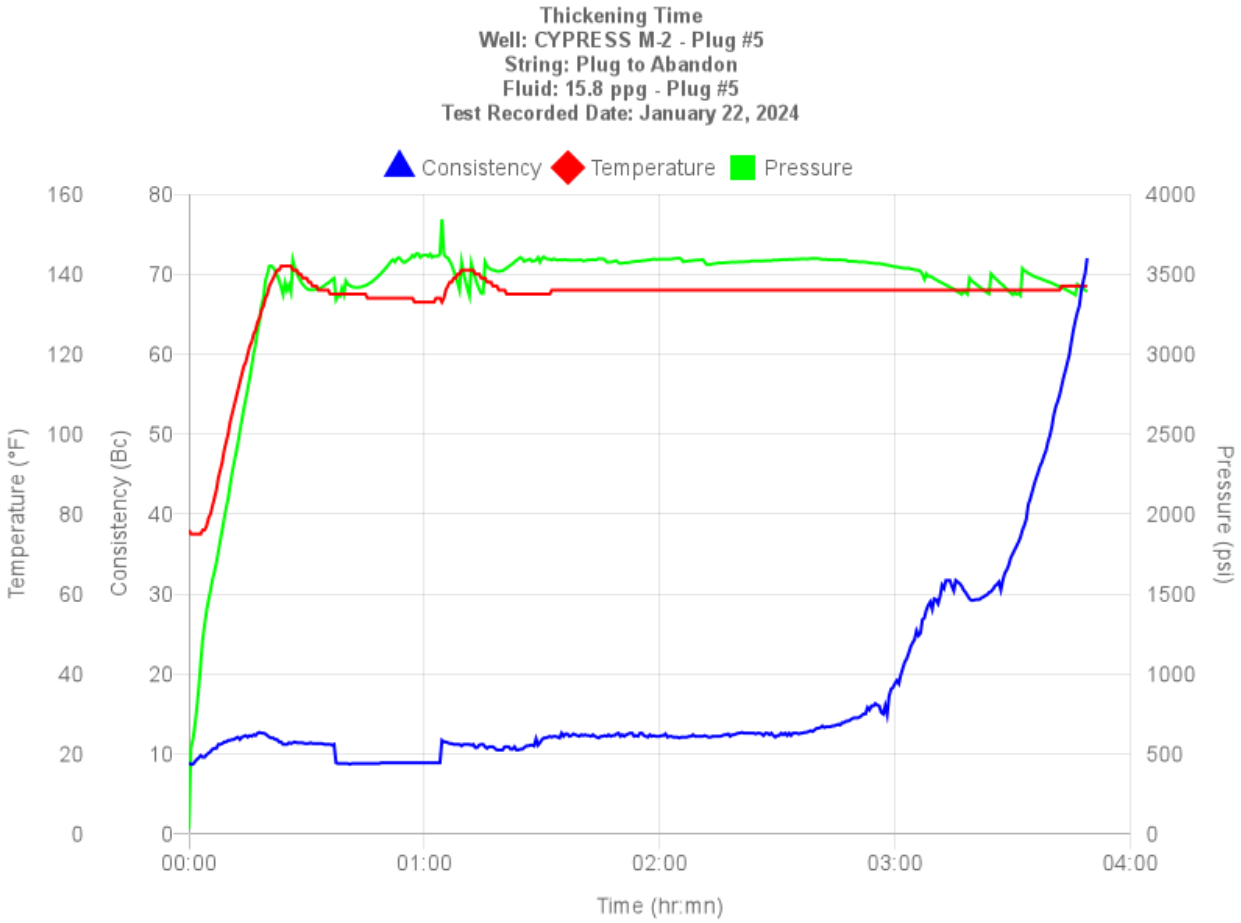
All slurries prepared and tested in accordance with SLB WIT Laboratory Standard Work Instructions.

Mixability assessment: **00:17 mn:sc** to add solids to blender. Vortex quality was **good/visible** after all solids added.
At time of lab testing base fluid temperature was **61 °F**, and blend temperature was **53 °F**

Water sample comment: Chloride content of water sample used for slurry testing was **<300** ppm

Synapse UID: **280615**

Liquid additives (if used) are added to the mix water in the following order prior to adding dry blend: Gas migration additive is injected to the water in the blender first at 4000rpm; then anti-foam; followed last by other liquids.



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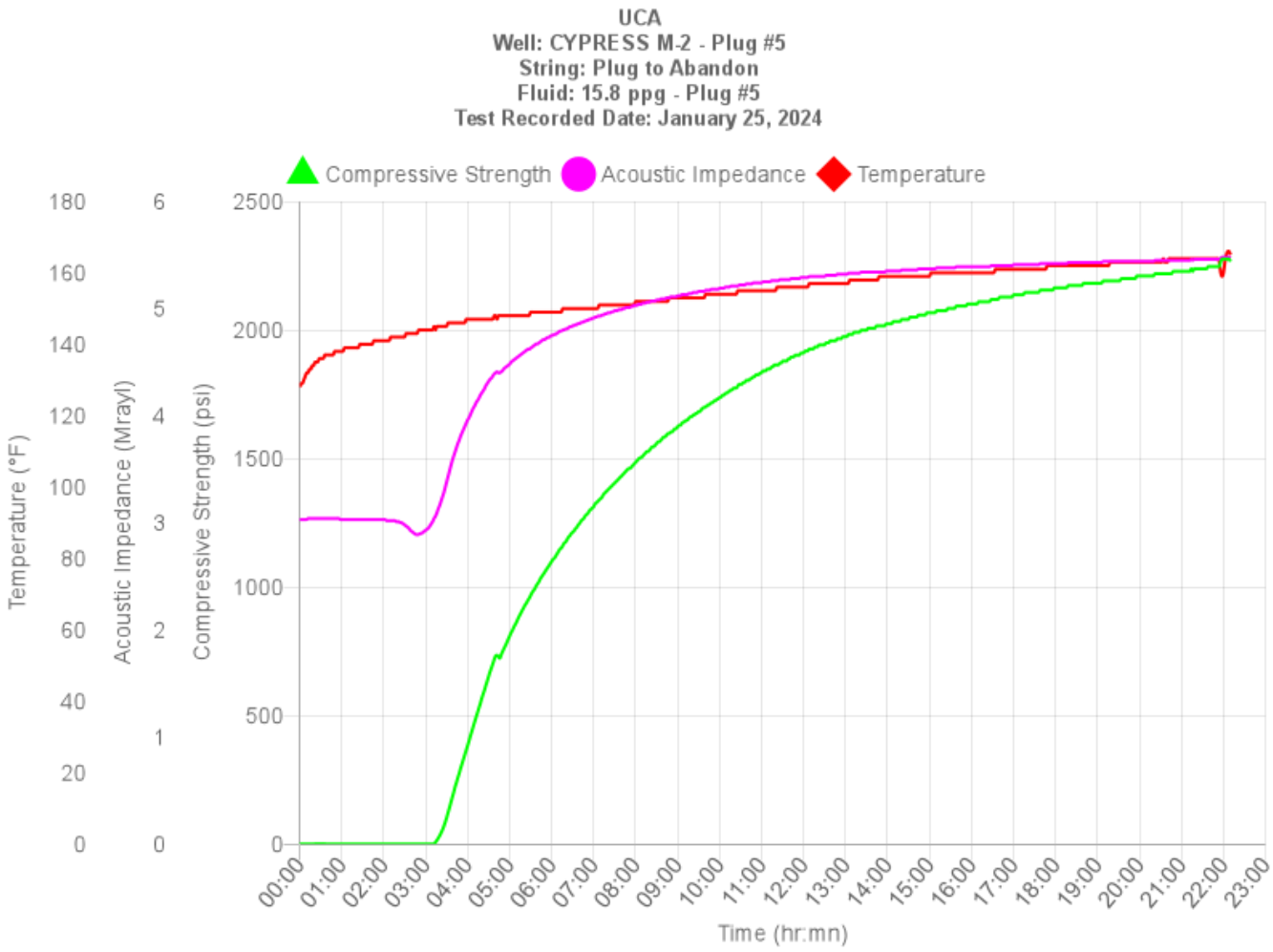





Schlumberger-Private

# WCO 2024-19 – Tallgrass Energy – True Drilling #38 – CYPRESS M-2 - Plug #6 – PlugToAbandon – 15.8 ppg - Plug #6 - Lab Report

| | | | |
|---|---|---|---|
| Jan-25-2024 | Casing: 5 | District: Windsor, CO | Design Input By: Andrew Barros |
| BHCT / BHST | 142 / 189 °F | BHP: 3,600 psi | MD / TVD: 7,142.00 / 7,142.00 ft |

## Composition Pilot Version 1

| | | | | | |
|---|---|---|---|---|---|
| Slurry Density | 15.80 lb/gal | Yield | 1.16 ft³/sk of blend | Mix Fluid | 5.165 gal/sk SackOfBlend |
| Solid Vol. Fraction | 40.62 % | Slurry Type | Plug w/ Spacer | Mix Water | 5.045 gal/sk SackOfBlend |
| Blend Sack | 94.00 lb | Blend Density | 3.20 SG | | |

| Code | Concentration | Component | Lot Number |
|---|---|---|---|
| D907 | 100.00 % BWOB | Cement | BULK |
| D801 | 0.050 gal/sk VBWOB | Retarder | 07R-11 |
| D080 | 0.050 gal/sk VBWOB | Dispersant | 8R3B0011E0 |
| D047 | 0.020 gal/sk VBWOB | Anti Foam | 04182021 |
| D153 | 0.30 % BWOB | Anti-Settling Agent | 9T26M23D-6 |
| Rig Water | 5.045 gal/sk of blend | Base Fluid | 1/11/24 |

**Surface Rheology**

| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
|---|---|---|---|
| 300 | 73 | 73 | 73 |
| 200 | 53 | 54 | 54 |
| 100 | 30 | 30 | 30 |
| 60 | 21 | 20 | 21 |
| 30 | 15 | 13 | 14 |
| 6 | 7 | 5 | 6 |
| 3 | 5 | 4 | 5 |
| 10 sec Gel | 13 deg - 14 lbf/100ft² | | |
| 10 min Gel | 17 deg - 18 lbf/100ft² | | |
| Bingham $P_V$ | 69 cP | | |
| Bingham $T_y$ | 6 lbf/100ft² | | |
| Measured Temp | 80 °F | | |
| Viscometer I.D. | S/N 384 with R1B1 F1.0 | | |

**Downhole Rheology**

| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
|---|---|---|---|
| 300 | 61 | 61 | 61 |
| 200 | 47 | 42 | 45 |
| 100 | 28 | 25 | 27 |
| 60 | 20 | 15 | 18 |
| 30 | 14 | 10 | 12 |
| 6 | 6 | 4 | 5 |
| 3 | 4 | 4 | 4 |
| 10 sec Gel | 5 deg - 5 lbf/100ft² | | |
| 10 min Gel | 13 deg - 14 lbf/100ft² | | |
| Bingham $P_V$ | 57 cP | | |
| Bingham $T_y$ | 5 lbf/100ft² | | |
| Measured Temp | 142 °F | | |
| Viscometer I.D. | S/N with 384 R1B1 F1.0 | | |

## Free Fluid

| |
|---|
| **0%** (0 mL / 250 mL) in 2 hrs at 65 °F and 0 deg inclination |
| Sedimentation: None |
| Test Method: Ambient |
| Cylinder Dimensions: 215x35 mm |

## Thickening Time Thickening Time 1

| Consistency | Time |
|---|---|
| KSQR TT | 03:46 to 04:46 hr:mn |
| POD | 04:29 hr:mn |
| 30 Bc | 04:48 hr:mn |
| 50 Bc | 05:07 hr:mn |
| 70 Bc | 05:16 hr:mn |
| Go/No-Go | Motor off at n/a for n/a |
| Consistometer S/N | 1359R |
| Set Conditions | SetHard |

## UCA Compressive Strength UCA 2: 100% cement

| Time | Compressive Strength | Acoustic Impedance |
|---|---|---|
| 03:23 hr:mn | 50 psi | 3.22 Mrayl |
| 04:12 hr:mn | 500 psi | 4.13 Mrayl |
| 00:00 hr:mn | 0 psi | 0.00 Mrayl |
| 00:00 hr:mn | 0 psi | 0.00 Mrayl |
| Machine S/N: | 808L | |

## Comments

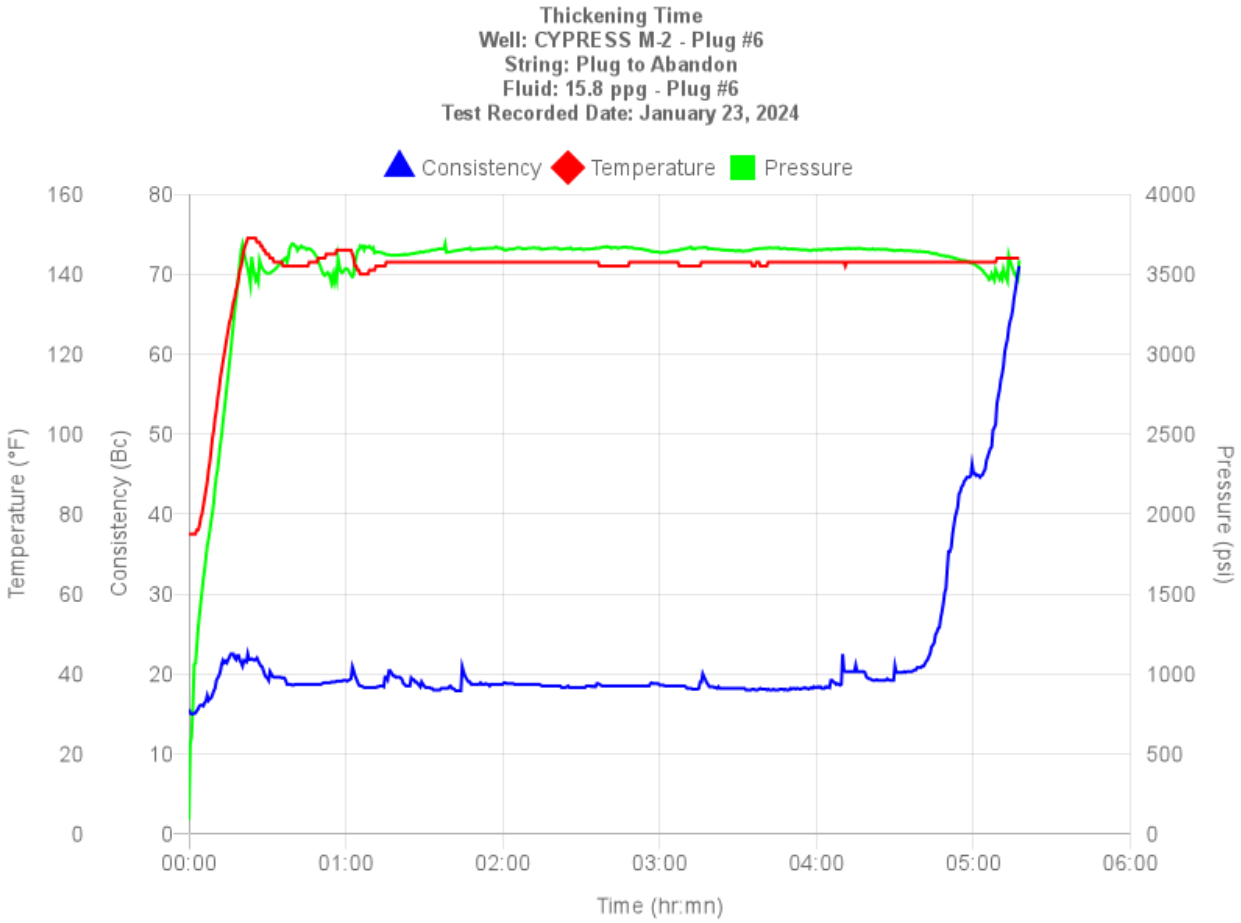
All slurries prepared and tested in accordance with SLB WIT Laboratory Standard Work Instructions.

Mixability assessment: **00:17 mn:sc** to add solids to blender. Vortex quality was **good/visible** after all solids added.
At time of lab testing base fluid temperature was **64 °F**, and blend temperature was **63 °F**

Water sample comment: Chloride content of water sample used for slurry testing was **<300** ppm

Synapse UID: **280612**

Liquid additives (if used) are added to the mix water in the following order prior to adding dry blend: Gas migration additive is injected to the water in the blender first at 4000rpm; then anti-foam; followed last by other liquids.



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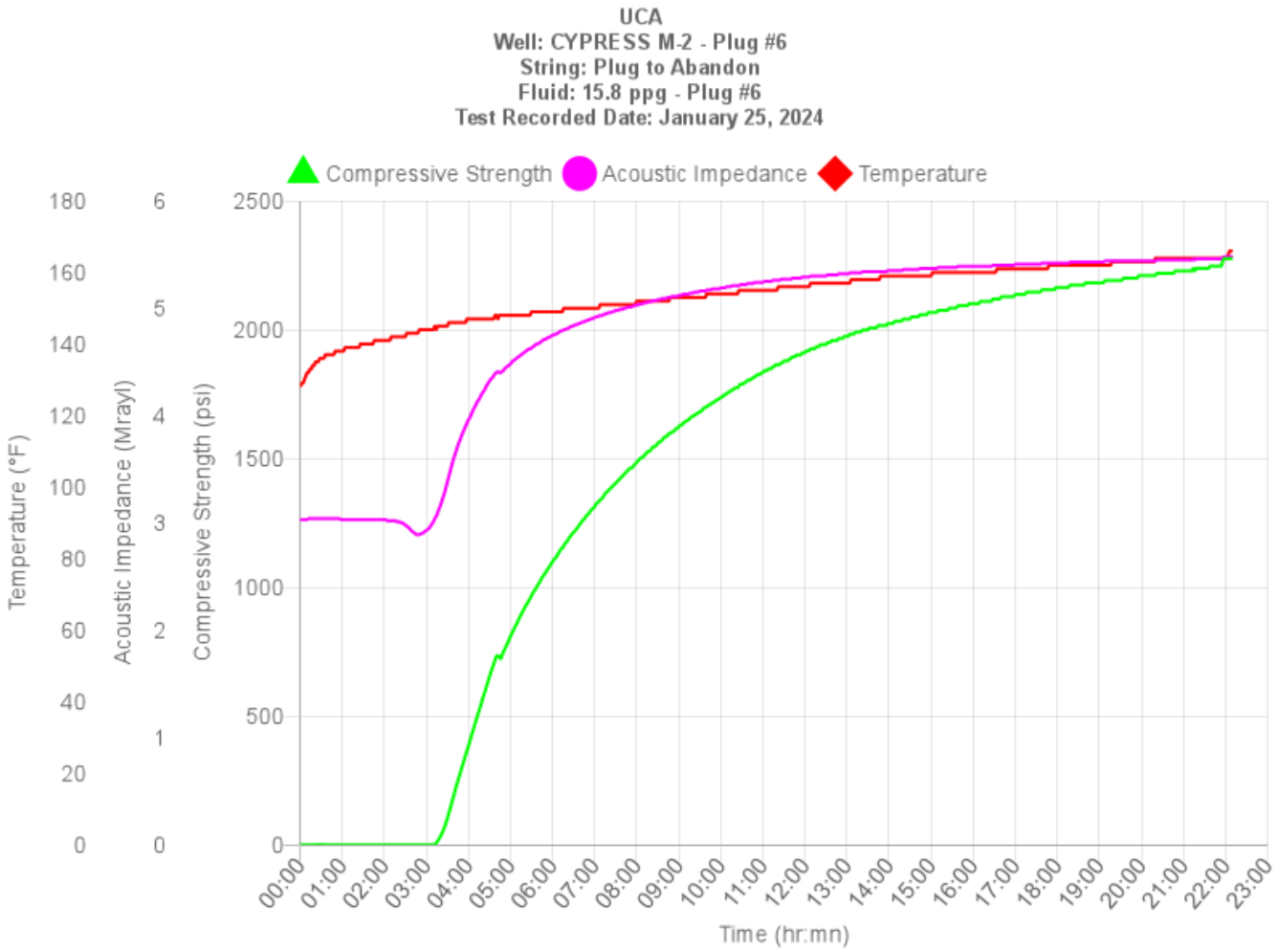





Schlumberger-Private

# WCO 2023-154 – Tallgrass Energy – True Drilling #38 – CYPRESS M-2 - Plug #7 – PlugToAbandon – 15.8 ppg - Plug #7 - Lab Report

| | | | |
|---|---|---|---|
| Jan-24-2024 | Casing: 5 | District: Windsor, CO | Design Input By: Sol Maldonado-Aviles |
| BHCT / BHST | 159 / 210 °F | BHP: 4,400 psi | MD / TVD: 8,311.00 / 8,311.00 ft |

## Composition Pilot Version 1

| | | | | | |
|---|---|---|---|---|---|
| Slurry Density | 15.80 lb/gal | Yield | 1.53 ft³/sk of blend | Mix Fluid | 6.431 gal/sk SackOfBlend |
| Solid Vol. Fraction | 43.84 % | Slurry Type | Plug w/ Spacer | Mix Water | 6.271 gal/sk SackOfBlend |
| Blend Sack | 94.00 lb | Blend Density | 3.20 SG | | |

| Code | Concentration | Component | Lot Number |
|---|---|---|---|
| D907 | 100.00 % BWOB | Cement | BULK |
| D801 | 0.070 gal/sk VBWOB | Retarder | 07R-11 |
| D080 | 0.070 gal/sk VBWOB | Dispersant | 8R3B0011E0 |
| D047 | 0.020 gal/sk VBWOB | Anti Foam | 04182021 |
| D066 | 35.00 % BWOB | Silica | Bulk |
| D153 | 0.30 % BWOB | Anti-Settling Agent | 9T26M23D-6 |
| Rig Water | 6.271 gal/sk of blend | Base Fluid | 1/11/24 |

**Surface Rheology**

| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
|---|---|---|---|
| 300 | 75 | 75 | 75 |
| 200 | 53 | 54 | 54 |
| 100 | 31 | 30 | 31 |
| 60 | 22 | 20 | 21 |
| 30 | 15 | 13 | 14 |
| 6 | 9 | 5 | 7 |
| 3 | 5 | 4 | 5 |
| 10 sec Gel | 14 deg - 15 lbf/100ft² | | |
| 10 min Gel | 19 deg - 20 lbf/100ft² | | |
| Bingham $P_V$ | 70 cP | | |
| Bingham $T_y$ | 6 lbf/100ft² | | |
| Measured Temp | 80 °F | | |
| Viscometer I.D. | S/N 384 with R1B1 F1.0 | | |

**Downhole Rheology**

| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
|---|---|---|---|
| 300 | 63 | 63 | 63 |
| 200 | 47 | 42 | 45 |
| 100 | 28 | 14 | 21 |
| 60 | 21 | 15 | 18 |
| 30 | 14 | 9 | 12 |
| 6 | 6 | 4 | 5 |
| 3 | 4 | 3 | 4 |
| 10 sec Gel | 0 deg - 0 lbf/100ft² | | |
| 10 min Gel | 0 deg - 0 lbf/100ft² | | |
| Bingham $P_V$ | 59 cP | | |
| Bingham $T_y$ | 4 lbf/100ft² | | |
| Measured Temp | 159 °F | | |
| Viscometer I.D. | S/N with 384 R1B1 F1.0 | | |

## Free Fluid

| |
|---|
| **0%** (0 mL / 250 mL) in 2 hrs at 63 °F and 0 deg inclination |
| Sedimentation: None |
| Test Method: Ambient |
| Cylinder Dimensions: 215x35 mm |

## Thickening Time Thickening Time 1

| Consistency | Time |
|---|---|
| KSQR TT | 04:22 to 05:22 hr:mn |
| POD | 06:37 hr:mn |
| 30 Bc | 07:15 hr:mn |
| 50 Bc | 07:22 hr:mn |
| 70 Bc | 07:27 hr:mn |
| Go/No-Go | Motor off at n/a for n/a |
| Consistometer S/N | 1359R |
| Set Conditions | SetHard |

## UCA Compressive Strength UCA 2: 100% cement

| Time | Compressive Strength | Acoustic Impedance |
|---|---|---|
| 14:17 hr:mn | 50 psi | 3.27 Mrayl |
| 15:03 hr:mn | 500 psi | 4.15 Mrayl |
| 12:00 hr:mn | 0 psi | 0.00 Mrayl |
| 24:00 hr:mn | 1978 psi | 5.33 Mrayl |
| Machine S/N: | 808R | |

## Comments

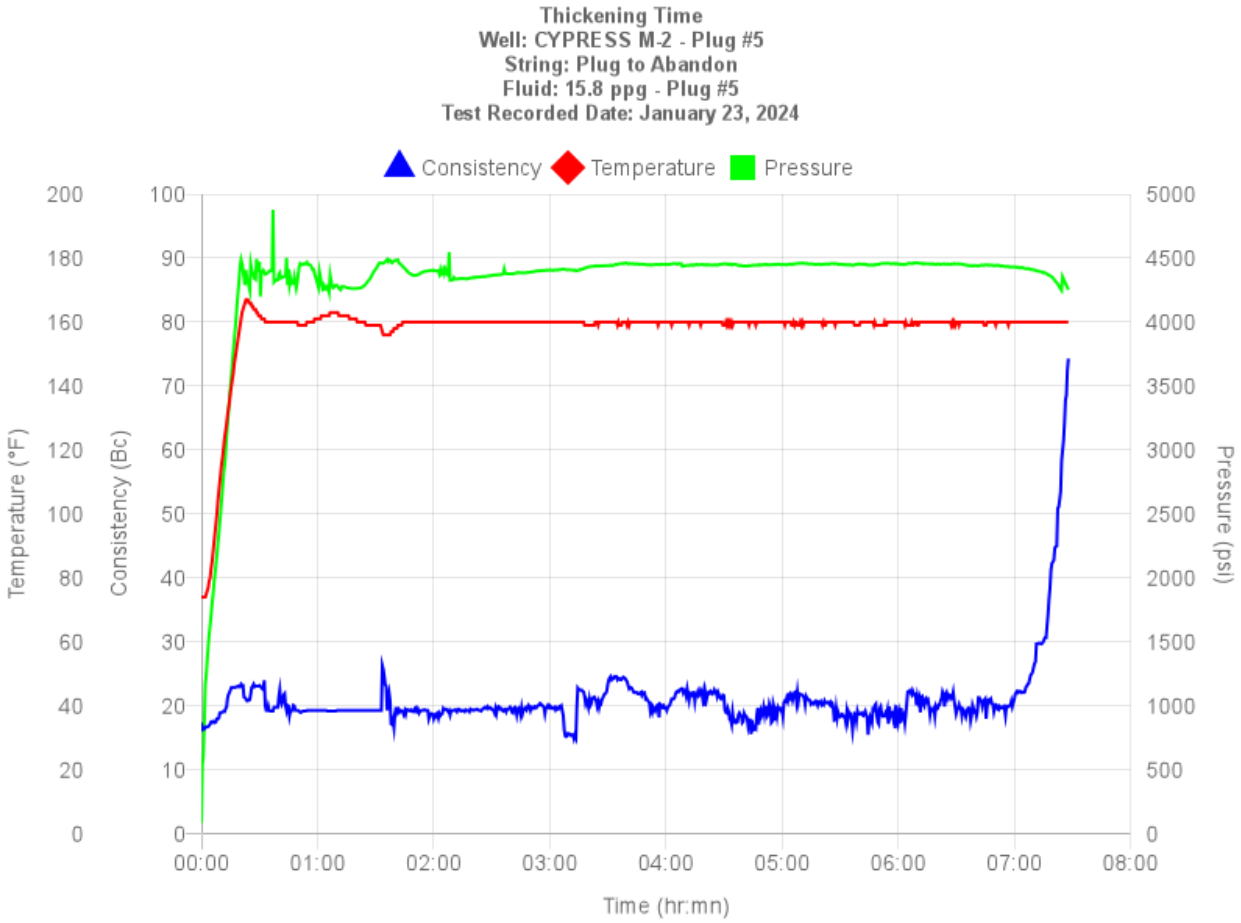
All slurries prepared and tested in accordance with SLB WIT Laboratory Standard Work Instructions.

Mixability assessment: **00:18 mn:sc** to add solids to blender. Vortex quality was **good/visible** after all solids added.
At time of lab testing base fluid temperature was **62 °F**, and blend temperature was **55 °F**

Water sample comment: Chloride content of water sample used for slurry testing was **<300** ppm

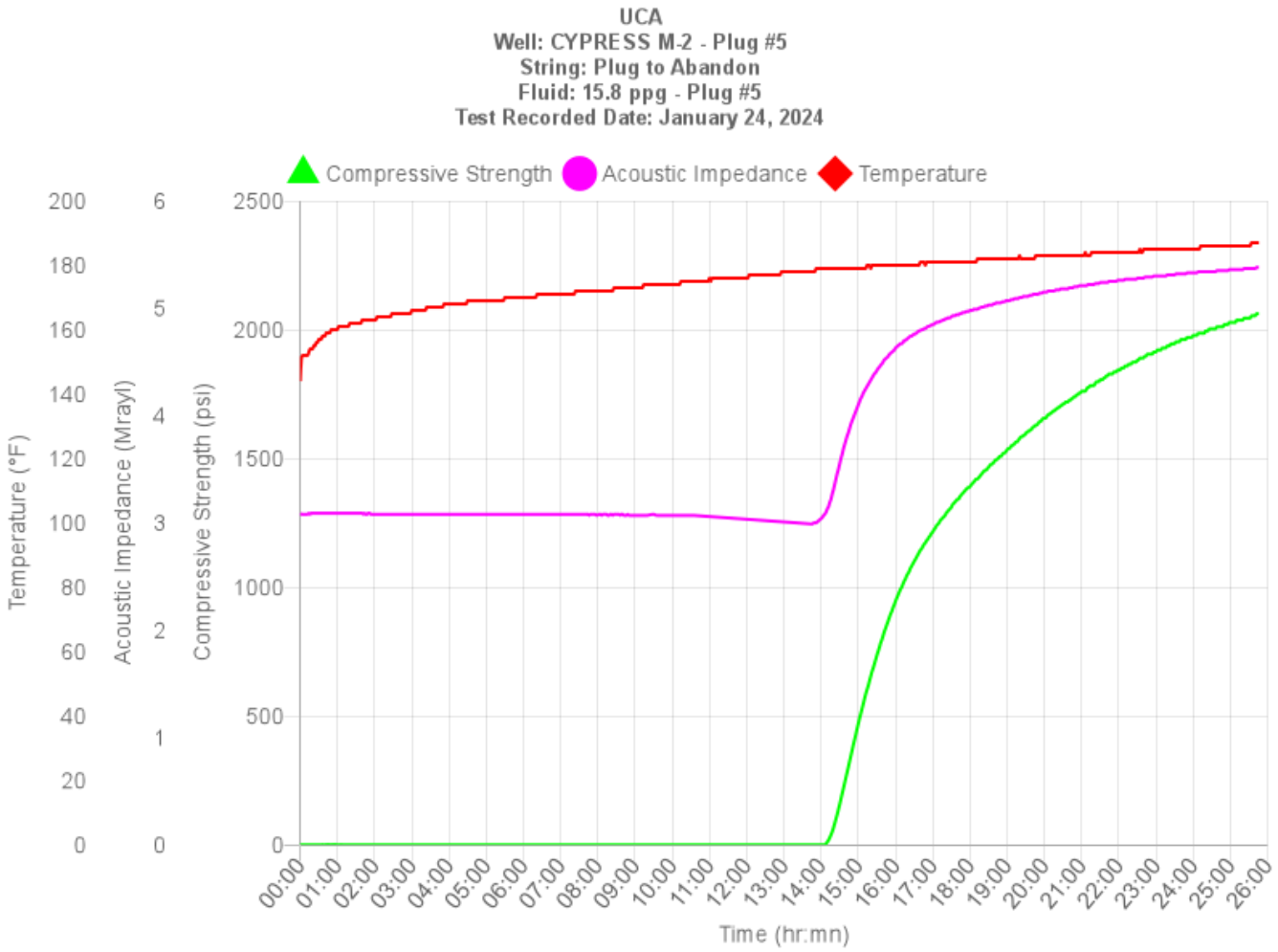
Synapse UID: **280662**

Liquid additives (if used) are added to the mix water in the following order prior to adding dry blend: Gas migration additive is injected to the water in the blender first at 4000rpm; then anti-foam; followed last by other liquids.






Schlumberger-Private






Schlumberger-Private

# WCO 2024-18 – Tallgrass Energy – True Drilling #38 – CYPRESS M-2 - Plug #8 – PlugToAbandon – EverCRETE Plug 6 w/ D197 - Lab Report

| | | | |
|---|---|---|---|
| Jan-24-2024 | Casing: 5 | District: Windsor, CO | Design Input By: Andrew Barros |
| BHCT / BHST | 172 / 221 °F | BHP: 4,700 psi | MD / TVD: 8,928.00 / 8,928.00 ft |

## Composition Confirmation Version 1

| | | | | | |
|---|---|---|---|---|---|
| Slurry Density | 15.80 lb/gal | Yield | 2.08 ft³/sk of blend | Mix Fluid | 6.588 gal/sk SackOfCement |
| Solid Vol. Fraction | 58.00 % | Slurry Type | Plug w/ Spacer | Mix Water | 6.456 gal/sk SackOfCement |
| Cement Sack | 55.00 lb | Blend Density | 2.52 SG | | |

| Code | Concentration | Component | Lot Number |
|---|---|---|---|
| EverCRETE | 100 % BWOB | Blend | Bulk |
| D065 | 0.10 % BWOB | Dispersant | 501565 |
| D167A | 0.25 % BWOB | Fluid loss | PPRC1118 |
| D197 | 0.050 gal/sk VBWOB | Retarder | KK1F0016A0 |
| D047 | 0.020 gal/sk VBWOB | Anti Foam | 04182021 |
| D153 | 0.10 % BWOB | Anti-Settling Agent | 9T26M23D-6 |
| D176 | 2.90 % BWOB | Expanding Agent | 2Y3K011241 |
| Rig Water | 6.456 gal/sk of blend | Base Fluid | 1/11/24 |

**Surface Rheology**

| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
|---|---|---|---|
| 300 | 121 | 121 | 121 |
| 200 | 95 | 92 | 94 |
| 100 | 62 | 57 | 60 |
| 60 | 46 | 42 | 44 |
| 30 | 31 | 29 | 30 |
| 6 | 19 | 16 | 18 |
| 3 | 16 | 14 | 15 |
| 10 sec Gel | 18 deg - 19 lbf/100ft² | | |
| 10 min Gel | 42 deg - 45 lbf/100ft² | | |
| Bingham $P_V$ | 107 cP | | |
| Bingham $T_y$ | 19 lbf/100ft² | | |
| Measured Temp | 80 °F | | |
| Viscometer I.D. | S/N 384 with R1B1 F1.0 | | |

**Downhole Rheology**

| Rotor rpm | Up (deg) | Down (deg) | Average (deg) |
|---|---|---|---|
| 300 | 148 | 148 | 148 |
| 200 | 108 | 106 | 107 |
| 100 | 65 | 61 | 63 |
| 60 | 46 | 41 | 44 |
| 30 | 28 | 23 | 25 |
| 6 | 9 | 7 | 8 |
| 3 | 7 | 5 | 6 |
| 10 sec Gel | 9 deg - 10 lbf/100ft² | | |
| 10 min Gel | 26 deg - 28 lbf/100ft² | | |
| Bingham $P_V$ | 142 cP | | |
| Bingham $T_y$ | 10 lbf/100ft² | | |
| Measured Temp | 172 °F | | |
| Viscometer I.D. | S/N with 384 R1B1 F1.0 | | |

## Free Fluid

| |
|---|
| **0%** (0 mL / 250 mL) in 2 hrs at 62 °F and 0 deg inclination |
| Sedimentation: None |
| Test Method: Ambient |
| Cylinder Dimensions: 215x35 mm |

## Fluid Loss

| |
|---|
| API Calculated Fluid Loss = **44.00 mL** |
| 22.00 mL collected in 30 mins at 172 °F |
| Filter Cake - Height: 30 mm. Consistency: Firm |
| Static press was utilized with temp measured in jacket wall |

## Thickening Time Thickening Time 1

| Consistency | Time |
|---|---|
| KSQR TT | 04:18 to 05:18 hr:mn |
| POD | 03:57 hr:mn |
| 30 Bc | 00:06 hr:mn |
| 50 Bc | 04:34 hr:mn |
| 70 Bc | 04:41 hr:mn |
| Go/No-Go | Motor off at 00:48 for 00:37 |
| Consistometer S/N | 754 |
| Set Conditions | SetHard |

## UCA Compressive Strength UCA 1: 80:20

Cement:Spacer

| Time | Compressive Strength | Acoustic Impedance |
|---|---|---|
| 10:30 hr:mn | 50 psi | 3.35 Mrayl |
| 14:23 hr:mn | 500 psi | 4.19 Mrayl |
| 12:00 hr:mn | 202 psi | 3.71 Mrayl |
| 17:00 hr:mn | 929 psi | 4.64 Mrayl |
| Machine S/N: | 904R | |

## Comments

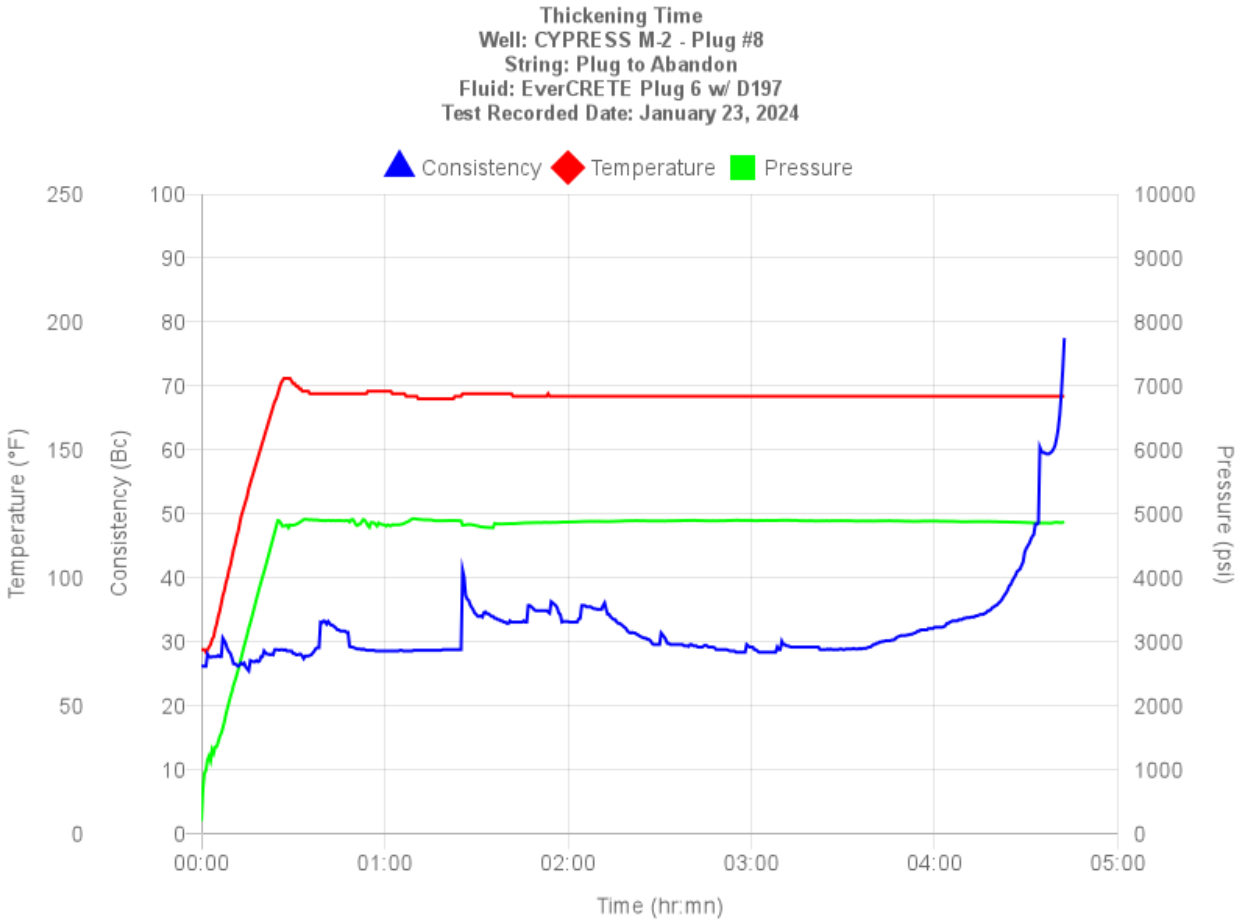
All slurries prepared and tested in accordance with SLB WIT Laboratory Standard Work Instructions.

Mixability assessment: **00:21 mn:sc** to add solids to blender. Vortex quality was **good/visible** after all solids added.
At time of lab testing base fluid temperature was **60 °F**, and blend temperature was **50 °F**

Water sample comment: Chloride content of water sample used for slurry testing was **<300** ppm

Synapse UID: **280505**

Liquid additives (if used) are added to the mix water in the following order prior to adding dry blend: Gas migration additive is injected to the water in the blender first at 4000rpm; then anti-foam; followed last by other liquids.



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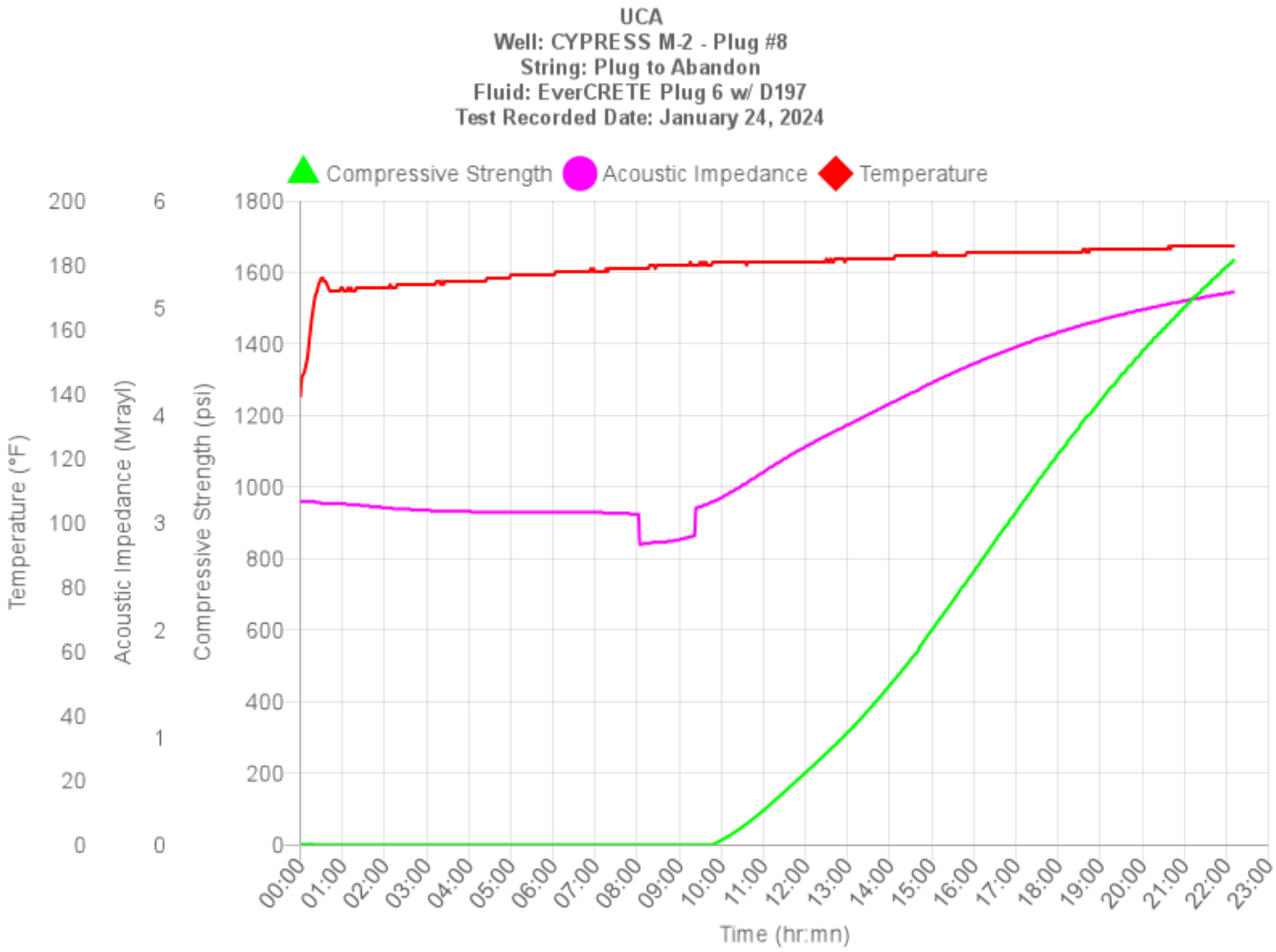




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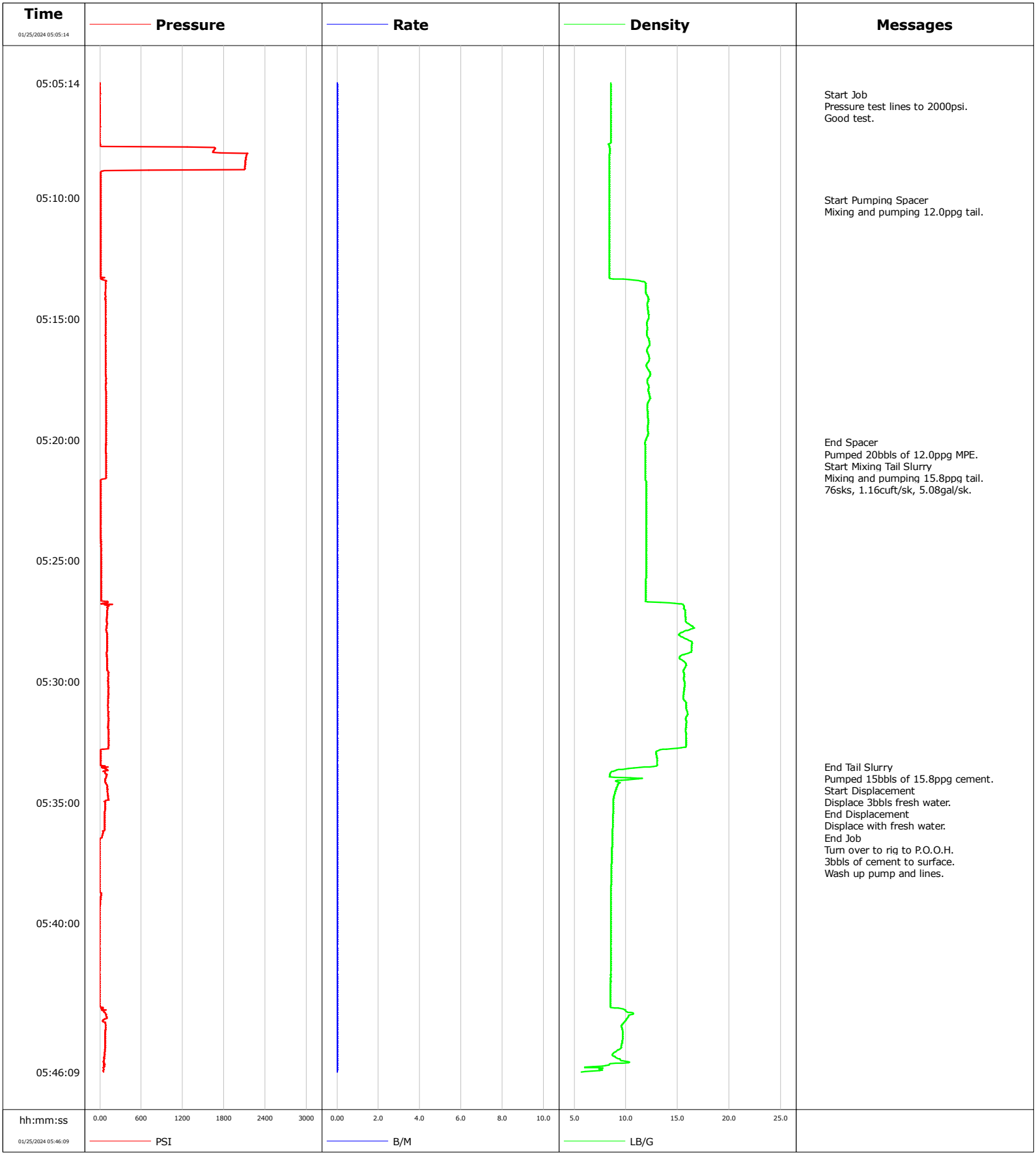
# Schlumberger

# Cementing Job Report



| | | | |
|---|---|---|---|
| **Well** | CYPRESS M-2 | **Client** | TALLGRASS ENERGY |
| **Field** | | **SIR No.** | EQX9-00083 |
| **Engineer** | JEFFREY PATTERSON | **Job Type** | SURFACE PLUG |
| **Country** | United States | **Job Date** | 01-25-2024 |



Schlumberger

# Cementing Service Report

| Customer | Job Number |
|---|---|
| TALLGRASS ENERGY | EQX9-00083 |

| Well | Location (legal) | Schlumberger Location | Job Start |
|---|---|---|---|
| CYPRESS M-2 M-2 | | WINDSOR | Jan/25/2024 |

| Field | Formation Name/Type | Deviation | Bit Size | Well MD | Well TVD |
|---|---|---|---|---|---|
| | | deg | in | 200.0 ft | ft |

| County | State/Province | BHP | BHST | BHCT | Pore Press. Gradient |
|---|---|---|---|---|---|
| LARAMIE | Wyoming | psi | degF | degF | lb/gal |

| Well Master | API/UWI |
|---|---|
| 0067006788 | 49-021-29598-00-00 |

| Rig Name | Drilled For | Service Via |
|---|---|---|
| TRUE 38 | Injection (Gas) | Land |

| Offshore Zone | Well Class | Well Type |
|---|---|---|
| | New | Exploration |

| Drilling Fluid Type | Max. Density | Plastic Viscosity |
|---|---|---|
| | lb/gal | cP |

| Service Line | Job Type |
|---|---|
| Cementing | SURFACE PLUG |

| Max. Allowed Tub. Press | Max. Allowed Ann. Press | WH Connection |
|---|---|---|
| psi | psi | 4 1/2" IF DP pin |

**Service Instructions**

76SKS, 1.16CUFT/SK, 5.08GAL/SK= 15.5BBLS. OF 15.8PPG TAIL.

**Casing/Liner**

| Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|
| | | | | |
| | | | | |

**Tubing/Drill Pipe**

| T/D | Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|---|
| D | 200.0 | 5.0 | 19.5 | | |
| | 0.0 | 0.0 | 0.0 | | |

**Perforations/Open Hole**

| Top, ft | Bottom, ft | shot/ft | No. of Shots | Total Interval |
|---|---|---|---|---|
| ft | ft | | | ft |
| ft | ft | | | Diameter |
| ft | ft | | | in |

| Treat Down | Displacement | Packer Type | Packer Depth |
|---|---|---|---|
| Drill Pipe | 3.0 bbl | | ft |

| Tubing Vol. | Casing Vol. | Annular Vol. | Openhole Vol. |
|---|---|---|---|
| 3.0 bbl | bbl | bbl | bbl |

| Casing/Tubing Secured | 1 Hole Vol. Circulated prior to Cement |
|---|---|
| X | X |

| Lift Pressure | | |
|---|---|---|
| psi | | |

| Pipe Rotated | Pipe Reciprocated |
|---|---|
| ☐ | ☐ |

| No. Centralizers | Top Plugs | Bottom Plugs |
|---|---|---|
| | | |

| Cement Head Type |
|---|
| |

| Job Scheduled For | Arrived on Location | Leave Location |
|---|---|---|
| Jan/25/2024 05:00 | Jan/25/2024 05:00 | Jan/25/2024 07:00 |

| Casing Tools | | Squeeze Job | |
|---|---|---|---|
| Shoe Type | | Squeeze Type | |
| Shoe Depth | ft | Tool Type | |
| Stage Tool Type | | Tool Depth | ft |
| Stage Tool Depth | ft | Tail Pipe Size | in |
| Collar Type | | Tail Pipe Depth | ft |
| Collar Depth | ft | Sqz. Total Vol. | bbl |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/25/2024 | 05:05:14 | 0 | 0.0 | 8.53 | 56.3 | 0 | Started Acquisition |
| 01/25/2024 | 05:05:43 | -0 | 0.0 | 8.53 | 56.3 | 0 | Start Job |
| 01/25/2024 | 05:05:45 | -1 | 0.0 | 8.53 | 56.3 | 0 | Pressure test lines to 2000psi. |
| 01/25/2024 | 05:05:46 | -1 | 0.0 | 8.53 | 56.3 | 0 | Good test. |
| 01/25/2024 | 05:06:44 | -1 | 0.0 | 8.53 | 0.0 | 0 | |
| 01/25/2024 | 05:08:14 | 2129 | 0.1 | 8.42 | 0.0 | 0 | |
| 01/25/2024 | 05:09:44 | 12 | 0.0 | 8.41 | 0.0 | 0 | |
| 01/25/2024 | 05:10:04 | 10 | 0.0 | 8.41 | 0.0 | 0 | Start Pumping Spacer |
| 01/25/2024 | 05:10:06 | 11 | 0.0 | 8.41 | 0.0 | 0 | Mixing and pumping 12.0ppg tail. |
| 01/25/2024 | 05:11:14 | 10 | 0.0 | 8.41 | 0.0 | 0 | |
| 01/25/2024 | 05:12:44 | 10 | 0.0 | 8.41 | 0.0 | 0 | |
| 01/25/2024 | 05:14:14 | 80 | 2.5 | 12.19 | 0.0 | 0 | |
| 01/25/2024 | 05:15:44 | 80 | 2.5 | 12.08 | 3.1 | 0 | |
| 01/25/2024 | 05:17:14 | 84 | 2.5 | 12.35 | 6.7 | 0 | |
| 01/25/2024 | 05:18:44 | 90 | 2.4 | 12.09 | 10.3 | 0 | |
| 01/25/2024 | 05:20:06 | 87 | 2.4 | 11.86 | 13.6 | 0 | End Spacer |
| 01/25/2024 | 05:20:08 | 87 | 2.4 | 11.85 | 13.7 | 0 | Pumped 20bbls of 12.0ppg MPE. |
| 01/25/2024 | 05:20:14 | 85 | 2.4 | 11.87 | 13.9 | 0 | Start Mixing Tail Slurry |
| 01/25/2024 | 05:20:16 | 87 | 2.4 | 11.88 | 14.0 | 0 | Mixing and pumping 15.8ppg tail. |
| 01/25/2024 | 05:21:44 | 7 | 0.1 | 11.97 | 17.5 | 0 | |
| 01/25/2024 | 05:23:14 | 13 | 0.0 | 11.96 | 17.5 | 0 | |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/25/2024 | TALLGRASS ENERGY | EQX9-00083 |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/25/2024 | 05:26:14 | 15 | 0.0 | 11.91 | 17.5 | 0 | |
| 01/25/2024 | 05:27:44 | 98 | 2.0 | 16.48 | 19.7 | 0 | |
| 01/25/2024 | 05:29:14 | 103 | 2.1 | 15.77 | 22.6 | 0 | |
| 01/25/2024 | 05:30:44 | 119 | 2.4 | 15.56 | 26.1 | 0 | |
| 01/25/2024 | 05:32:14 | 125 | 2.4 | 15.81 | 29.6 | 0 | |
| 01/25/2024 | 05:33:31 | 38 | 0.6 | 12.71 | 31.1 | 0 | End Tail Slurry |
| 01/25/2024 | 05:33:33 | 119 | 0.9 | 11.78 | 31.1 | 0 | Pumped 15bbls of 15.8ppg cement. |
| 01/25/2024 | 05:33:36 | 92 | 0.8 | 10.27 | 31.2 | 0 | Start Displacement |
| 01/25/2024 | 05:33:37 | 76 | 0.9 | 9.98 | 31.2 | 0 | Displace 3bbls fresh water. |
| 01/25/2024 | 05:33:44 | 56 | 1.4 | 8.63 | 31.4 | 0 | |
| 01/25/2024 | 05:34:56 | 81 | 2.3 | 8.77 | 34.1 | 0 | End Displacement |
| 01/25/2024 | 05:34:57 | 79 | 1.9 | 8.77 | 34.2 | 0 | Displace with fresh water. |
| 01/25/2024 | 05:35:03 | 78 | 0.1 | 8.79 | 34.3 | 0 | End Job |
| 01/25/2024 | 05:35:05 | 78 | 0.1 | 8.78 | 34.3 | 0 | Turn over to rig to P.O.O.H. |
| 01/25/2024 | 05:35:14 | 74 | 0.1 | 8.78 | 34.3 | 0 | |
| 01/25/2024 | 05:36:44 | -1 | 0.2 | 8.68 | 34.5 | 0 | |
| 01/25/2024 | 05:38:14 | -3 | 0.2 | 8.58 | 34.8 | 0 | |
| 01/25/2024 | 05:39:44 | -3 | 0.2 | 8.54 | 35.1 | 0 | |
| 01/25/2024 | 05:41:14 | -3 | 0.2 | 8.53 | 35.4 | 0 | |
| 01/25/2024 | 05:42:44 | -3 | 0.2 | 8.52 | 35.8 | 0 | |
| 01/25/2024 | 05:44:14 | 83 | 2.4 | 9.58 | 37.6 | 0 | |

## Post Job Summary

| Average Pump Rates, bbl/min | | | | Volume of Fluid Injected, bbl | | | |
|---|---|---|---|---|---|---|---|
| Slurry | N2 | Mud | Maximum Rate | Total Slurry | Mud | Spacer | N2 |
| 1.4 | | | 11.6 | 15.0 | 0.0 | 20.0 | |

| Treating Pressure Summary, psi | | | | | Breakdown Fluid | | |
|---|---|---|---|---|---|---|---|
| Maximum | Final | Average | Bump Plug to | Breakdown | Type | Volume | Density |
| 2138 | 51 | 119 | | | | bbl | lb/gal |

| Avg. N2 Percent | Designed Slurry Volume | Displacement | Mix Water Temp | | |
|---|---|---|---|---|---|
| % | 15.5 bbl | 3.0 bbl | 60 degF | Cement Circulated to Surface? [X] | Volume 3.0 bbl |
| | | | | Washed Thru Perfs [ ] | To ft |

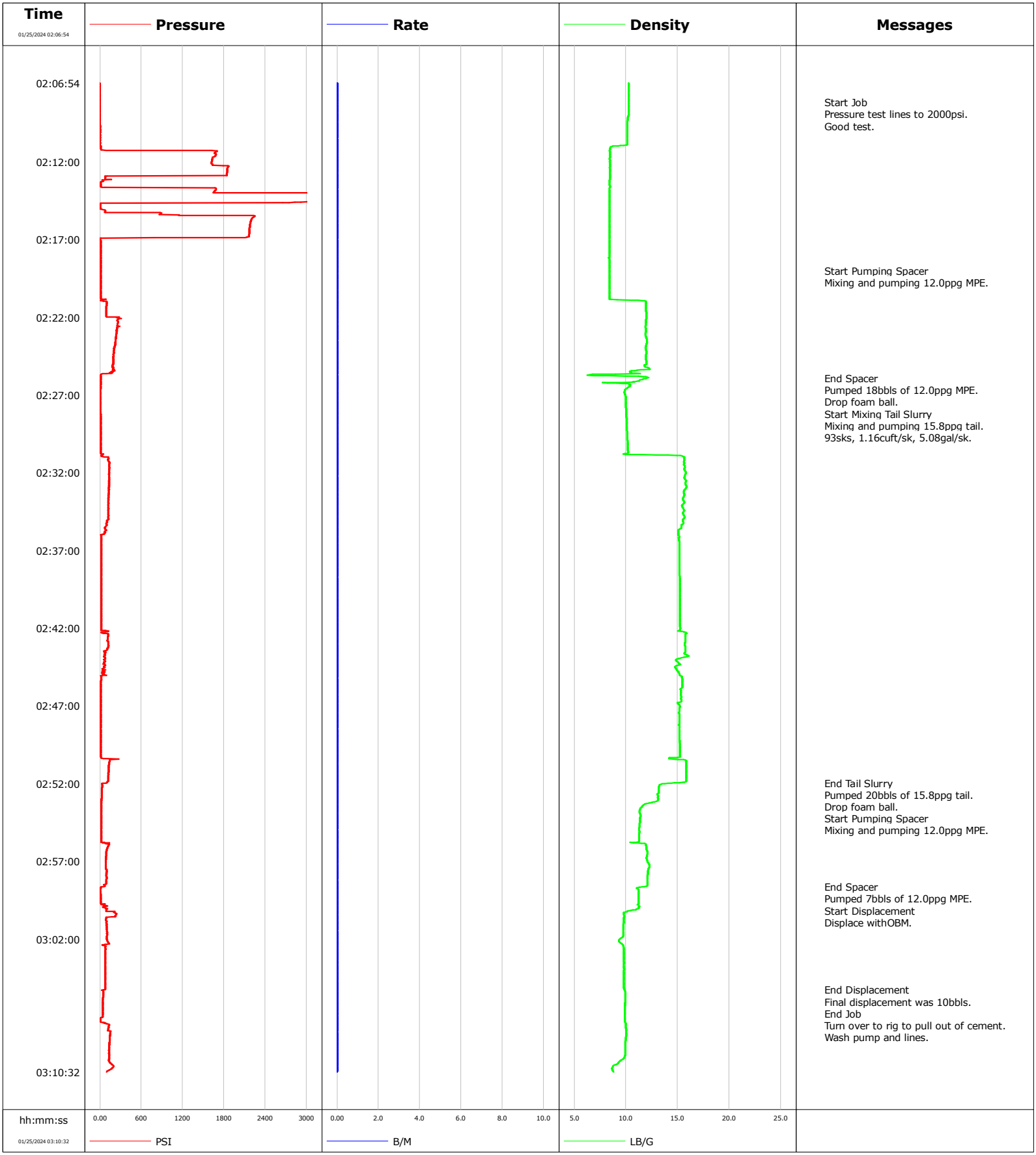
| Customer or Authorized Representative | Schlumberger Supervisor | Circulation Lost | Job Completed |
|---|---|---|---|
| | JEFFREY PATTERSON | - | [X] - |

# Schlumberger

# Cementing Job Report



| | | | |
|---|---|---|---|
| **Well** | CYPRESS M-2 | **Client** | TALLGRASS ENERGY |
| **Field** | | **SIR No.** | EQX9-00083 |
| **Engineer** | JEFFREY PATTERSON | **Job Type** | PLUG 7 |
| **Country** | United States | **Job Date** | 01-25-2024 |



Schlumberger

# Cementing Service Report

| Customer | Job Number |
|---|---|
| TALLGRASS ENERGY | EQX9-00083 |

| Well | Location (legal) | Schlumberger Location | Job Start |
|---|---|---|---|
| CYPRESS M-2 M-2 | | WINDSOR | Jan/25/2024 |

| Field | Formation Name/Type | Deviation | Bit Size | Well MD | Well TVD |
|---|---|---|---|---|---|
| | | deg | in | 1652.0 ft | ft |

| County | State/Province | BHP | BHST | BHCT | Pore Press. Gradient |
|---|---|---|---|---|---|
| LARAMIE | Wyoming | psi | degF | degF | lb/gal |

| Well Master | API/UWI |
|---|---|
| 0067006788 | 49-021-29598 |

| Rig Name | Drilled For | Service Via |
|---|---|---|
| TRUE 38 | Injection (Gas) | Land |

| Offshore Zone | Well Class | Well Type |
|---|---|---|
| | New | Exploration |

| Drilling Fluid Type | Max. Density | Plastic Viscosity |
|---|---|---|
| | lb/gal | cP |

| Service Line | Job Type |
|---|---|
| Cementing | PLUG 7 |

| Max. Allowed Tub. Press | Max. Allowed Ann. Press | WH Connection |
|---|---|---|
| psi | psi | 4 1/2" IF DP pin |

**Service Instructions**

93sks, 1.16cuft/sk, 5.08gal/sk= 20bbls of 15.8ppg tail.

**Casing/Liner**

| Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|
| | | | | |
| | | | | |

**Tubing/Drill Pipe**

| T/D | Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|---|
| D | 1652.0 | 5.0 | 19.5 | | |
| | 0.0 | 0.0 | 0.0 | | |

**Perforations/Open Hole**

| Top, ft | Bottom, ft | shot/ft | No. of Shots | Total Interval |
|---|---|---|---|---|
| ft | ft | | | ft |
| ft | ft | | | Diameter |
| ft | ft | | | in |

| Treat Down | Displacement | Packer Type | Packer Depth |
|---|---|---|---|
| Drill Pipe | 8.0 bbl | | ft |

| Tubing Vol. | Casing Vol. | Annular Vol. | Openhole Vol. |
|---|---|---|---|
| 13.0 bbl | bbl | bbl | bbl |

| Casing/Tubing Secured | 1 Hole Vol. Circulated prior to Cement |
|---|---|
| X | X |

| Lift Pressure | psi |
|---|---|

| Pipe Rotated | Pipe Reciprocated |
|---|---|
| ☐ | ☐ |

| No. Centralizers | Top Plugs | Bottom Plugs |
|---|---|---|
| | | |

| Cement Head Type |
|---|
| |

| Job Scheduled For | Arrived on Location | Leave Location |
|---|---|---|
| Jan/25/2024 02:00 | Jan/25/2024 02:00 | Jan/25/2024 04:00 |

| Casing Tools | | Squeeze Job | |
|---|---|---|---|
| Shoe Type | | Squeeze Type | |
| Shoe Depth | ft | Tool Type | |
| Stage Tool Type | | Tool Depth | ft |
| Stage Tool Depth | ft | Tail Pipe Size | in |
| Collar Type | | Tail Pipe Depth | ft |
| Collar Depth | ft | Sqz. Total Vol. | bbl |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/25/2024 | 02:06:54 | -6 | 1.3 | 10.28 | 78.2 | 0 | Started Acquisition |
| 01/25/2024 | 02:08:09 | -5 | 1.3 | 10.28 | 78.2 | 0 | Start Job |
| 01/25/2024 | 02:08:11 | -6 | 1.3 | 10.28 | 78.2 | 0 | Pressure test lines to 2000psi. |
| 01/25/2024 | 02:08:24 | -6 | 1.3 | 10.28 | 78.2 | 0 | |
| 01/25/2024 | 02:09:54 | 1 | 1.6 | 10.13 | 0.3 | 0 | |
| 01/25/2024 | 02:11:24 | 1670 | 0.0 | 8.46 | 2.1 | 0 | |
| 01/25/2024 | 02:12:54 | 101 | 0.0 | 8.44 | 2.2 | 0 | |
| 01/25/2024 | 02:14:24 | 3066 | 0.0 | 8.41 | 0.2 | 0 | |
| 01/25/2024 | 02:15:54 | 2182 | 0.0 | 8.41 | 0.3 | 0 | |
| 01/25/2024 | 02:17:24 | 9 | 0.0 | 8.40 | 0.3 | 0 | |
| 01/25/2024 | 02:18:54 | 10 | 0.0 | 8.40 | 0.3 | 0 | |
| 01/25/2024 | 02:18:59 | 10 | 0.0 | 8.40 | 0.3 | 0 | Start Pumping Spacer |
| 01/25/2024 | 02:19:02 | 9 | 0.0 | 8.40 | 0.3 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/25/2024 | 02:20:24 | 10 | 0.0 | 8.41 | 0.3 | 0 | |
| 01/25/2024 | 02:21:54 | 90 | 1.7 | 11.97 | 2.5 | 0 | |
| 01/25/2024 | 02:23:24 | 230 | 4.2 | 12.01 | 8.6 | 0 | |
| 01/25/2024 | 02:24:54 | 193 | 4.2 | 11.97 | 14.9 | 0 | |
| 01/25/2024 | 02:25:54 | 11 | 0.5 | 12.02 | 18.1 | 0 | End Spacer |
| 01/25/2024 | 02:25:56 | 11 | 0.8 | 11.92 | 18.1 | 0 | Pumped 18bbls of 12.0ppg MPE. |
| 01/25/2024 | 02:25:57 | 11 | 0.4 | 11.72 | 18.1 | 0 | Drop foam ball. |
| 01/25/2024 | 02:26:02 | 10 | 0.0 | 11.37 | 18.1 | 0 | Start Mixing Tail Slurry |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/25/2024 | TALLGRASS ENERGY | EQX9-00083 |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/25/2024 | 02:26:05 | 10 | 0.7 | 11.29 | 18.1 | 0 | 93sks, 1.16cuft/sk, 5.08gal/sk. |
| 01/25/2024 | 02:26:24 | 7 | 0.0 | 10.42 | 18.2 | 0 | |
| 01/25/2024 | 02:27:54 | 6 | 0.0 | 10.01 | 18.2 | 0 | |
| 01/25/2024 | 02:29:24 | 13 | 0.0 | 10.10 | 18.2 | 0 | |
| 01/25/2024 | 02:30:54 | 19 | 0.8 | 15.26 | 18.4 | 0 | |
| 01/25/2024 | 02:32:24 | 130 | 2.3 | 15.71 | 21.8 | 0 | |
| 01/25/2024 | 02:33:54 | 121 | 2.4 | 15.64 | 25.4 | 0 | |
| 01/25/2024 | 02:35:24 | 94 | 2.1 | 15.33 | 28.8 | 0 | |
| 01/25/2024 | 02:36:54 | 17 | 0.0 | 15.16 | 30.0 | 0 | |
| 01/25/2024 | 02:38:24 | 17 | 0.0 | 15.19 | 30.0 | 0 | |
| 01/25/2024 | 02:39:54 | 17 | 0.0 | 15.21 | 30.0 | 0 | |
| 01/25/2024 | 02:41:24 | 16 | 0.0 | 15.23 | 30.0 | 0 | |
| 01/25/2024 | 02:42:54 | 120 | 2.3 | 15.74 | 31.4 | 0 | |
| 01/25/2024 | 02:44:24 | 78 | 1.8 | 14.93 | 34.3 | 0 | |
| 01/25/2024 | 02:45:54 | 13 | 0.1 | 15.26 | 35.3 | 0 | |
| 01/25/2024 | 02:47:24 | 13 | 0.0 | 15.14 | 35.4 | 0 | |
| 01/25/2024 | 02:48:54 | 13 | 0.0 | 15.19 | 35.4 | 0 | |
| 01/25/2024 | 02:50:24 | 103 | 0.7 | 14.18 | 35.4 | 0 | |
| 01/25/2024 | 02:51:54 | 103 | 2.2 | 15.70 | 38.9 | 0 | |
| 01/25/2024 | 02:51:57 | 96 | 2.1 | 14.68 | 39.0 | 0 | End Tail Slurry |
| 01/25/2024 | 02:51:59 | 41 | 1.8 | 14.10 | 39.1 | 0 | Pumped 20bbls of 15.8ppg tail. |
| 01/25/2024 | 02:52:01 | 22 | 1.0 | 13.56 | 39.1 | 0 | Drop foam ball. |
| 01/25/2024 | 02:52:06 | 31 | 0.1 | 13.23 | 39.2 | 0 | Start Pumping Spacer |
| 01/25/2024 | 02:52:08 | 30 | 0.0 | 13.23 | 39.2 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/25/2024 | 02:53:24 | 20 | 0.0 | 11.64 | 39.2 | 0 | |
| 01/25/2024 | 02:54:54 | 20 | 0.0 | 11.28 | 39.2 | 0 | |
| 01/25/2024 | 02:56:24 | 91 | 2.5 | 12.07 | 40.5 | 0 | |
| 01/25/2024 | 02:57:54 | 92 | 2.7 | 12.09 | 44.3 | 0 | |
| 01/25/2024 | 02:58:37 | 55 | 2.2 | 11.78 | 46.1 | 0 | End Spacer |
| 01/25/2024 | 02:58:39 | 10 | 1.4 | 11.38 | 46.2 | 0 | Pumped 7bbls of 12.0ppg MPE. |
| 01/25/2024 | 02:58:44 | 9 | 0.3 | 11.09 | 46.3 | 0 | Start Displacement |
| 01/25/2024 | 02:58:50 | 7 | 0.0 | 11.21 | 46.3 | 0 | Displace withOBM. |
| 01/25/2024 | 02:59:24 | 9 | 0.0 | 11.21 | 46.3 | 0 | |
| 01/25/2024 | 03:00:54 | 91 | 2.0 | 9.80 | 49.1 | 0 | |
| 01/25/2024 | 03:02:24 | 39 | 0.5 | 9.76 | 52.1 | 0 | |
| 01/25/2024 | 03:03:54 | 76 | 1.7 | 9.81 | 54.1 | 0 | |
| 01/25/2024 | 03:05:16 | 56 | 1.3 | 9.86 | 56.2 | 0 | End Displacement |
| 01/25/2024 | 03:05:18 | 36 | 0.6 | 9.88 | 56.3 | 0 | Final displacement was 10bbls. |
| 01/25/2024 | 03:05:22 | 44 | 0.0 | 9.91 | 56.3 | 0 | End Job |
| 01/25/2024 | 03:05:24 | 44 | 0.0 | 9.91 | 56.3 | 0 | Turn over to rig to pull out of cement. |
| 01/25/2024 | 03:05:25 | 43 | 0.0 | 9.91 | 56.3 | 0 | Wash pump and lines. |
| 01/25/2024 | 03:08:24 | 138 | 2.3 | 9.98 | 56.3 | 0 | |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/25/2024 | TALLGRASS ENERGY | EQX9-00083 |

# Post Job Summary

| Average Pump Rates, bbl/min | | | | Volume of Fluid Injected, bbl | | | |
|---|---|---|---|---|---|---|---|
| Slurry | N2 | Mud | Maximum Rate | Total Slurry | Mud | Spacer | N2 |
| 1.4 | | | 5.0 | 20.0 | 0.0 | 25.0 | |

| Treating Pressure Summary, psi | | | | | Breakdown Fluid | | |
|---|---|---|---|---|---|---|---|
| Maximum | Final | Average | Bump Plug to | Breakdown | Type | Volume | Density |
| 3118 | 96 | 205 | | | | bbl | lb/gal |

| Avg. N2 Percent | Designed Slurry Volume | Displacement | Mix Water Temp | | |
|---|---|---|---|---|---|
| % | 20.0 bbl | 10.0 bbl | 60 degF | Cement Circulated to Surface? ☐ | Volume bbl |
| | | | | Washed Thru Perfs ☐ | To ft |

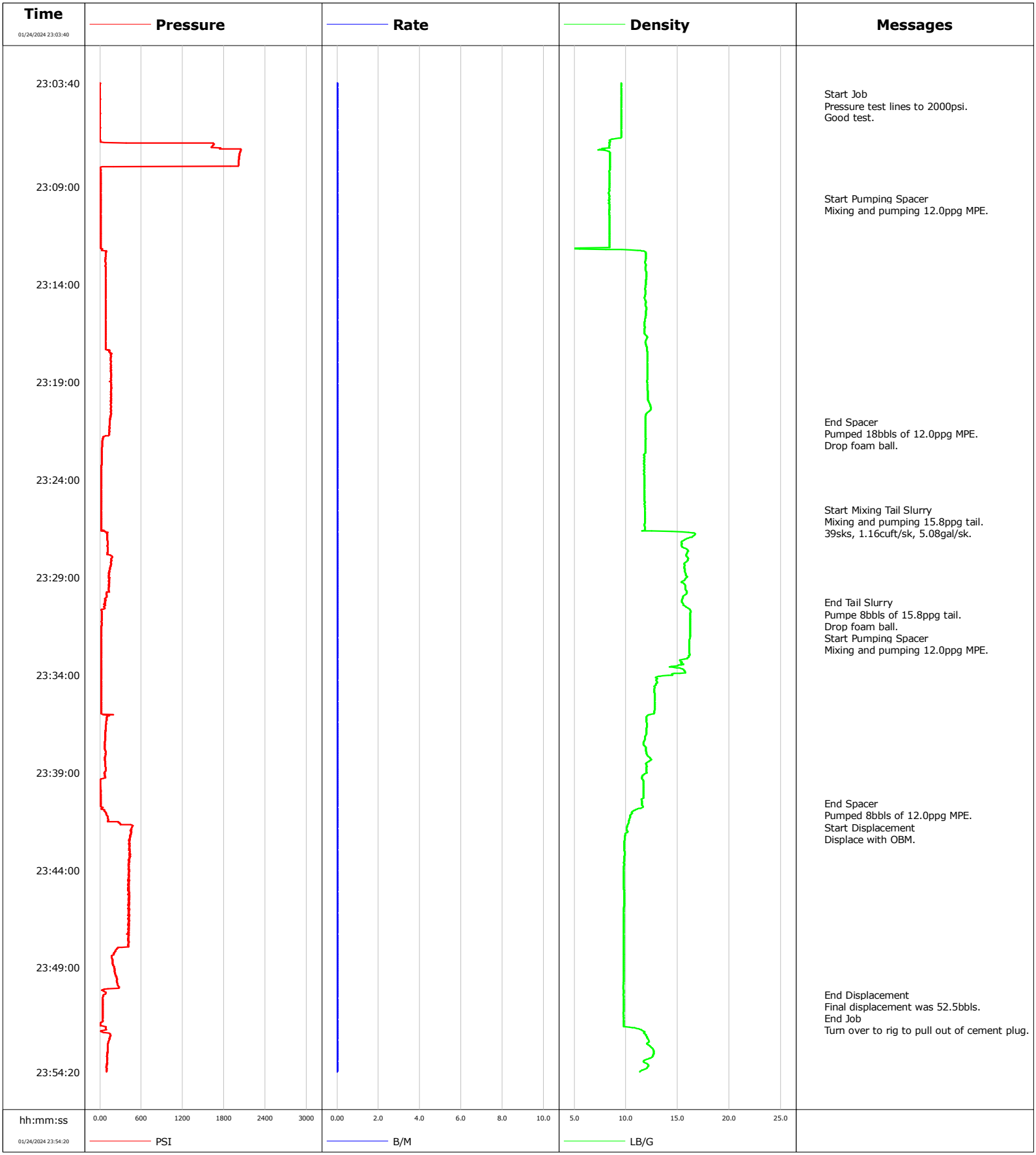
| Customer or Authorized Representative | Schlumberger Supervisor | Circulation Lost | Job Completed |
|---|---|---|---|
| | JEFFREY PATTERSON | ☐ | ☒ |
| | | - | - |

# Schlumberger

# Cementing Job Report



| | | | |
|---|---|---|---|
| **Well** | CYPRESS M-2 | **Client** | TALLGRASS ENERGY |
| **Field** | | **SIR No.** | EQX9-00083 |
| **Engineer** | JEFFREY PATTERSON | **Job Type** | PLUG 6 |
| **Country** | United States | **Job Date** | 01-24-2024 |



Schlumberger

# Cementing Service Report

| Customer | Job Number |
|---|---|
| TALLGRASS ENERGY | EQX9-00083 |

| Well | Location (legal) | Schlumberger Location | Job Start |
|---|---|---|---|
| CYPRESS M-2 M-2 | | WINDSOR | Jan/24/2024 |

| Field | Formation Name/Type | Deviation | Bit Size | Well MD | Well TVD |
|---|---|---|---|---|---|
| | | deg | in | 3519.0 ft | ft |

| County | State/Province | BHP | BHST | BHCT | Pore Press. Gradient |
|---|---|---|---|---|---|
| LARAMIE | Wyoming | psi | degF | degF | lb/gal |

| Well Master | API/UWI |
|---|---|
| 0067006788 | 49-021-29598-00-00 |

| Rig Name | Drilled For | Service Via |
|---|---|---|
| TRUE 38 | Injection (Gas) | Land |

| Offshore Zone | Well Class | Well Type |
|---|---|---|
| | New | Exploration |

| Drilling Fluid Type | Max. Density | Plastic Viscosity |
|---|---|---|
| | lb/gal | cP |

| Service Line | Job Type |
|---|---|
| Cementing | PLUG 6 |

| Max. Allowed Tub. Press | Max. Allowed Ann. Press | WH Connection |
|---|---|---|
| psi | psi | 4 1/2" IF DP pin |

**Service Instructions**

39SKS, 1.16CUFT/SK, 5.08GAL/SK= 8BBLS OF 15.8PPG TAIL.

**Casing/Liner**

| Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|
| | | | | |
| | | | | |

**Tubing/Drill Pipe**

| T/D | Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|---|
| D | 3519.0 | 5.0 | 19.5 | | |
| | 0.0 | 0.0 | 0.0 | | |

**Perforations/Open Hole**

| Top, ft | Bottom, ft | shot/ft | No. of Shots | Total Interval |
|---|---|---|---|---|
| ft | ft | | | ft |
| ft | ft | | | Diameter |
| ft | ft | | | in |

| Treat Down | Displacement | Packer Type | Packer Depth |
|---|---|---|---|
| Drill Pipe | 50.0 bbl | | ft |

| Tubing Vol. | Casing Vol. | Annular Vol. | Openhole Vol. |
|---|---|---|---|
| bbl | bbl | bbl | bbl |

| Casing/Tubing Secured | 1 Hole Vol. Circulated prior to Cement |
|---|---|
| X | X |

| Lift Pressure | psi |
|---|---|

| Pipe Rotated | Pipe Reciprocated |
|---|---|
| ☐ | ☐ |

| No. Centralizers | Top Plugs | Bottom Plugs |
|---|---|---|
| | | |

| Cement Head Type |
|---|
| |

| Job Scheduled For | Arrived on Location | Leave Location |
|---|---|---|
| Jan/24/2024 22:00 | Jan/24/2024 22:00 | Jan/24/2024 24:00 |

| Casing Tools | | Squeeze Job | |
|---|---|---|---|
| Shoe Type | | Squeeze Type | |
| Shoe Depth | ft | Tool Type | |
| Stage Tool Type | | Tool Depth | ft |
| Stage Tool Depth | ft | Tail Pipe Size | in |
| Collar Type | | Tail Pipe Depth | ft |
| Collar Depth | ft | Sqz. Total Vol. | bbl |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 23:03:40 | 0 | 0.0 | 9.56 | 114.6 | 0 | Started Acquisition |
| 01/24/2024 | 23:04:14 | -0 | 0.0 | 9.57 | 114.6 | 0 | Start Job |
| 01/24/2024 | 23:04:16 | -1 | 0.0 | 9.57 | 114.6 | 0 | Pressure test lines to 2000psi. |
| 01/24/2024 | 23:05:10 | -0 | 0.0 | 9.56 | 114.6 | 0 | |
| 01/24/2024 | 23:06:40 | 5 | 0.3 | 8.47 | 0.0 | 0 | |
| 01/24/2024 | 23:08:10 | 10 | 0.6 | 8.43 | 0.1 | 0 | |
| 01/24/2024 | 23:09:35 | 12 | 0.1 | 8.37 | 0.2 | 0 | Start Pumping Spacer |
| 01/24/2024 | 23:09:36 | 13 | 0.0 | 8.39 | 0.2 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/24/2024 | 23:09:40 | 12 | 0.0 | 8.40 | 0.2 | 0 | |
| 01/24/2024 | 23:11:10 | 13 | 0.0 | 8.41 | 0.2 | 0 | |
| 01/24/2024 | 23:12:40 | 79 | 2.4 | 11.92 | 1.4 | 0 | |
| 01/24/2024 | 23:14:10 | 81 | 1.3 | 11.87 | 3.7 | 0 | |
| 01/24/2024 | 23:15:40 | 82 | 1.3 | 11.89 | 5.7 | 0 | |
| 01/24/2024 | 23:17:10 | 84 | 1.2 | 11.99 | 7.6 | 0 | |
| 01/24/2024 | 23:18:40 | 158 | 2.3 | 12.06 | 10.8 | 0 | |
| 01/24/2024 | 23:21:01 | 142 | 2.3 | 11.89 | 16.2 | 0 | End Spacer |
| 01/24/2024 | 23:21:03 | 141 | 2.3 | 11.89 | 16.3 | 0 | Pumped 18bbls of 12.0ppg MPE. |
| 01/24/2024 | 23:21:06 | 142 | 2.3 | 11.89 | 16.4 | 0 | Drop foam ball. |
| 01/24/2024 | 23:21:40 | 135 | 2.3 | 11.88 | 17.7 | 0 | |
| 01/24/2024 | 23:23:10 | 23 | 0.0 | 11.74 | 18.1 | 0 | |
| 01/24/2024 | 23:24:40 | 19 | 0.0 | 11.80 | 18.1 | 0 | |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/24/2024 | TALLGRASS ENERGY | EQX9-00083 |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 23:25:34 | 19 | 0.0 | 11.81 | 18.1 | 0 | Mixing and pumping 15.8ppg tail. |
| 01/24/2024 | 23:26:10 | 19 | 0.0 | 11.82 | 18.1 | 0 | |
| 01/24/2024 | 23:27:40 | 108 | 1.6 | 16.01 | 19.8 | 0 | |
| 01/24/2024 | 23:29:10 | 137 | 2.3 | 15.65 | 23.2 | 0 | |
| 01/24/2024 | 23:30:17 | 67 | 1.7 | 15.40 | 25.5 | 0 | End Tail Slurry |
| 01/24/2024 | 23:30:18 | 77 | 1.6 | 15.43 | 25.6 | 0 | Pumpe 8bbls of 15.8ppg tail. |
| 01/24/2024 | 23:30:21 | 82 | 1.7 | 15.54 | 25.6 | 0 | Drop foam ball. |
| 01/24/2024 | 23:30:29 | 64 | 1.6 | 15.73 | 25.9 | 0 | Start Pumping Spacer |
| 01/24/2024 | 23:30:31 | 57 | 1.5 | 15.82 | 25.9 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/24/2024 | 23:30:40 | 17 | 0.9 | 16.20 | 26.1 | 0 | |
| 01/24/2024 | 23:32:10 | 18 | 0.0 | 16.17 | 26.2 | 0 | |
| 01/24/2024 | 23:33:40 | 18 | 0.0 | 15.32 | 26.2 | 0 | |
| 01/24/2024 | 23:35:10 | 18 | 0.0 | 12.80 | 26.2 | 0 | |
| 01/24/2024 | 23:36:40 | 81 | 2.6 | 12.01 | 27.5 | 0 | |
| 01/24/2024 | 23:38:10 | 74 | 2.5 | 12.16 | 31.3 | 0 | |
| 01/24/2024 | 23:39:40 | 6 | 0.1 | 11.70 | 34.2 | 0 | |
| 01/24/2024 | 23:40:35 | 7 | 0.0 | 11.54 | 34.2 | 0 | End Spacer |
| 01/24/2024 | 23:40:37 | 8 | 0.0 | 11.54 | 34.2 | 0 | Pumped 8bbls of 12.0ppg MPE. |
| 01/24/2024 | 23:40:41 | 8 | 0.0 | 11.56 | 34.2 | 0 | Start Displacement |
| 01/24/2024 | 23:40:42 | 8 | 0.0 | 11.60 | 34.2 | 0 | Displace with OBM. |
| 01/24/2024 | 23:41:10 | 98 | 2.4 | 10.46 | 34.9 | 0 | |
| 01/24/2024 | 23:42:40 | 429 | 5.5 | 9.84 | 41.7 | 0 | |
| 01/24/2024 | 23:44:10 | 416 | 5.5 | 9.80 | 50.0 | 0 | |
| 01/24/2024 | 23:45:40 | 420 | 5.5 | 9.81 | 58.2 | 0 | |
| 01/24/2024 | 23:47:10 | 422 | 5.5 | 9.78 | 66.5 | 0 | |
| 01/24/2024 | 23:48:40 | 179 | 3.2 | 9.78 | 73.4 | 0 | |
| 01/24/2024 | 23:50:10 | 28 | 0.6 | 9.78 | 78.1 | 0 | |
| 01/24/2024 | 23:50:23 | 54 | 0.2 | 9.76 | 78.2 | 0 | End Displacement |
| 01/24/2024 | 23:50:25 | 47 | 0.0 | 9.76 | 78.2 | 0 | Final displacement was 52.5bbls. |
| 01/24/2024 | 23:50:29 | 43 | 0.0 | 9.76 | 78.2 | 0 | End Job |
| 01/24/2024 | 23:50:30 | 43 | 0.0 | 9.76 | 78.2 | 0 | Turn over to rig to pull out of cement plug. |
| 01/24/2024 | 23:51:40 | 37 | 0.0 | 9.77 | 78.2 | 0 | |

## Post Job Summary

| Average Pump Rates, bbl/min | | | | Volume of Fluid Injected, bbl | | | |
|---|---|---|---|---|---|---|---|
| Slurry | N2 | Mud | Maximum Rate | Total Slurry | Mud | Spacer | N2 |
| 2.0 | | | 5.5 | 8.0 | 0.0 | 25.0 | |

| Treating Pressure Summary, psi | | | | | Breakdown Fluid | | |
|---|---|---|---|---|---|---|---|
| Maximum | Final | Average | Bump Plug to | Breakdown | Type | Volume | Density |
| 2049 | 77 | 167 | | | | bbl | lb/gal |

| Avg. N2 Percent | Designed Slurry Volume | Displacement | Mix Water Temp | Cement Circulated to Surface? | Volume |
|---|---|---|---|---|---|
| % | 8.0 bbl | 52.5 bbl | 60 degF | ☐ | bbl |
| | | | | Washed Thru Perfs ☐ | To ft |

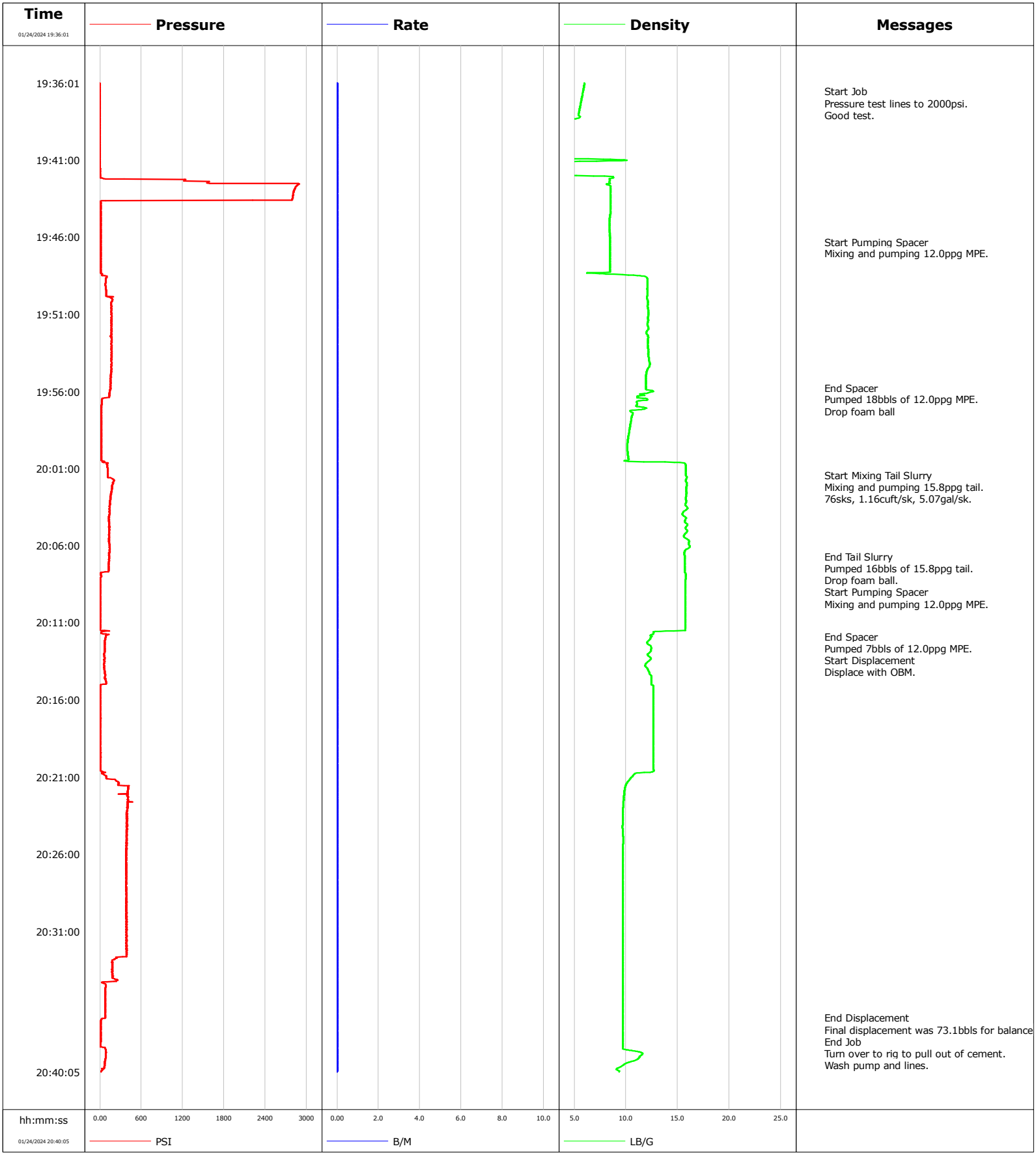
| Customer or Authorized Representative | Schlumberger Supervisor | Circulation Lost | Job Completed |
|---|---|---|---|
| | JEFFREY PATTERSON | - ☐ | - ☐ |

# Schlumberger

# Cementing Job Report



| | | | |
|---|---|---|---|
| **Well** | CYPRESS M-2 | **Client** | TALLGRASS ENERGY |
| **Field** | | **SIR No.** | EQX9-00083 |
| **Engineer** | JEFFREY PATTERSON | **Job Type** | PLUG 5 |
| **Country** | United States | **Job Date** | 01-24-2024 |



# Schlumberger Cementing Service Report

| Customer | Job Number |
|---|---|
| TALLGRASS ENERGY | EQX9-00083 |

| Well | Location (legal) | Schlumberger Location | Job Start |
|---|---|---|---|
| CYPRESS M-2 CYPRESS M-2 | | WINDSOR | Jan/24/2024 |

| Field | Formation Name/Type | Deviation | Bit Size | Well MD | Well TVD |
|---|---|---|---|---|---|
| | | deg | in | 5386.0 ft | ft |

| County | State/Province | BHP | BHST | BHCT | Pore Press. Gradient |
|---|---|---|---|---|---|
| LARAMIE | Wyoming | psi | degF | degF | lb/gal |

| Well Master | API/UWI |
|---|---|
| 0067006788 | 49-021-29598-00-00 |

| Rig Name | Drilled For | Service Via |
|---|---|---|
| TRUE 38 | Injection (Gas) | Land |

| Offshore Zone | Well Class | Well Type |
|---|---|---|
| | New | Exploration |

| Drilling Fluid Type | Max. Density | Plastic Viscosity |
|---|---|---|
| | lb/gal | cP |

| Service Line | Job Type |
|---|---|
| Cementing | PLUG 5 |

| Max. Allowed Tub. Press | Max. Allowed Ann. Press | WH Connection |
|---|---|---|
| psi | psi | 4 1/2" IF DP pin |

**Service Instructions**

76SKS, 1.16CUFT/SK, 5.07GAL/SK= 15.5BBLS OF 15.8PPG TAIL.

**Casing/Liner**

| Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|
| | | | | |
| | | | | |

**Tubing/Drill Pipe**

| T/D | Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|---|
| D | 5386.0 | 5.0 | 19.5 | | |
| | 0.0 | 0.0 | 0.0 | | |

**Perforations/Open Hole**

| Top, ft | Bottom, ft | shot/ft | No. of Shots | Total Interval |
|---|---|---|---|---|
| ft | ft | | | ft |
| ft | ft | | | Diameter |
| ft | ft | | | in |

| Treat Down | Displacement | Packer Type | Packer Depth |
|---|---|---|---|
| Drill Pipe | 80.0 bbl | | ft |

| Tubing Vol. | Casing Vol. | Annular Vol. | Openhole Vol. |
|---|---|---|---|
| 85.5 bbl | bbl | bbl | bbl |

| Casing/Tubing Secured | 1 Hole Vol. Circulated prior to Cement |
|---|---|
| X | X |

| Lift Pressure | | Pipe Rotated | Pipe Reciprocated |
|---|---|---|---|
| psi | | ☐ | ☐ |

| No. Centralizers | Top Plugs | Bottom Plugs |
|---|---|---|
| | | |

| Cement Head Type |
|---|
| |

| Job Scheduled For | Arrived on Location | Leave Location |
|---|---|---|
| Jan/24/2024 19:30 | Jan/24/2024 19:30 | Jan/24/2024 21:00 |

| Casing Tools | | Squeeze Job | |
|---|---|---|---|
| Shoe Type | | Squeeze Type | |
| Shoe Depth | ft | Tool Type | |
| Stage Tool Type | | Tool Depth | ft |
| Stage Tool Depth | ft | Tail Pipe Size | in |
| Collar Type | | Tail Pipe Depth | ft |
| Collar Depth | ft | Sqz. Total Vol. | bbl |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 19:36:01 | -6 | 1.4 | 5.99 | 129.6 | 0 | Started Acquisition |
| 01/24/2024 | 19:36:35 | -6 | 1.4 | 5.84 | 129.6 | 0 | Start Job |
| 01/24/2024 | 19:36:37 | -6 | 1.4 | 5.83 | 129.6 | 0 | Pressure test lines to 2000psi. |
| 01/24/2024 | 19:36:38 | -7 | 1.4 | 5.83 | 129.6 | 0 | Good test. |
| 01/24/2024 | 19:37:31 | -7 | 1.5 | 5.57 | 129.6 | 0 | |
| 01/24/2024 | 19:39:01 | -6 | 4.7 | 1.23 | 129.6 | 0 | |
| 01/24/2024 | 19:40:31 | -6 | 5.4 | 0.91 | 129.6 | 0 | |
| 01/24/2024 | 19:42:01 | 0 | 4.3 | 2.34 | 0.0 | 0 | |
| 01/24/2024 | 19:43:31 | 2794 | 0.0 | 8.49 | 0.0 | 0 | |
| 01/24/2024 | 19:45:01 | 14 | 0.0 | 8.42 | 0.1 | 0 | |
| 01/24/2024 | 19:46:19 | 13 | 0.0 | 8.43 | 0.1 | 0 | Start Pumping Spacer |
| 01/24/2024 | 19:46:21 | 13 | 0.0 | 8.43 | 0.1 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/24/2024 | 19:46:31 | 13 | 0.0 | 8.43 | 0.1 | 0 | |
| 01/24/2024 | 19:48:01 | 14 | 0.0 | 8.43 | 0.1 | 0 | |
| 01/24/2024 | 19:49:31 | 88 | 1.1 | 12.06 | 2.5 | 0 | |
| 01/24/2024 | 19:51:01 | 166 | 2.3 | 12.16 | 5.5 | 0 | |
| 01/24/2024 | 19:52:31 | 165 | 2.3 | 12.15 | 8.9 | 0 | |
| 01/24/2024 | 19:54:01 | 164 | 2.3 | 12.23 | 12.4 | 0 | |
| 01/24/2024 | 19:55:31 | 152 | 2.3 | 11.95 | 15.8 | 0 | |
| 01/24/2024 | 19:55:46 | 153 | 2.3 | 11.94 | 16.4 | 0 | End Spacer |
| 01/24/2024 | 19:55:48 | 150 | 2.3 | 11.95 | 16.5 | 0 | Pumped 18bbls of 12.0ppg MPE. |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 CYPRESS M-2 | | Jan/24/2024 | TALLGRASS ENERGY | EQX9-00083 |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 19:57:01 | 21 | 0.0 | 11.30 | 18.1 | 0 | |
| 01/24/2024 | 19:58:31 | 19 | 0.0 | 10.33 | 18.1 | 0 | |
| 01/24/2024 | 20:00:01 | 19 | 0.0 | 10.16 | 18.1 | 0 | |
| 01/24/2024 | 20:01:26 | 109 | 1.3 | 15.78 | 19.7 | 0 | Start Mixing Tail Slurry |
| 01/24/2024 | 20:01:28 | 109 | 1.3 | 15.81 | 19.8 | 0 | Mixing and pumping 15.8ppg tail. |
| 01/24/2024 | 20:01:29 | 110 | 1.3 | 15.82 | 19.8 | 0 | 76sks, 1.16cuft/sk, 5.07gal/sk. |
| 01/24/2024 | 20:01:31 | 110 | 1.3 | 15.88 | 19.8 | 0 | |
| 01/24/2024 | 20:03:01 | 152 | 2.3 | 15.77 | 23.2 | 0 | |
| 01/24/2024 | 20:04:31 | 130 | 2.3 | 15.75 | 26.6 | 0 | |
| 01/24/2024 | 20:06:01 | 142 | 2.3 | 16.16 | 30.1 | 0 | |
| 01/24/2024 | 20:06:43 | 130 | 2.4 | 15.69 | 31.8 | 0 | End Tail Slurry |
| 01/24/2024 | 20:06:44 | 132 | 2.4 | 15.69 | 31.8 | 0 | Pumped 16bbls of 15.8ppg tail. |
| 01/24/2024 | 20:06:47 | 130 | 2.4 | 15.69 | 31.9 | 0 | Drop foam ball. |
| 01/24/2024 | 20:06:55 | 130 | 2.4 | 15.70 | 32.2 | 0 | Start Pumping Spacer |
| 01/24/2024 | 20:06:56 | 130 | 2.4 | 15.70 | 32.3 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/24/2024 | 20:07:31 | 126 | 2.4 | 15.70 | 33.7 | 0 | |
| 01/24/2024 | 20:09:01 | 3 | 0.0 | 15.76 | 34.2 | 0 | |
| 01/24/2024 | 20:10:31 | 4 | 0.0 | 15.75 | 34.2 | 0 | |
| 01/24/2024 | 20:11:52 | 81 | 1.9 | 12.53 | 34.8 | 0 | End Spacer |
| 01/24/2024 | 20:11:54 | 80 | 1.8 | 12.49 | 34.9 | 0 | Pumped 7bbls of 12.0ppg MPE. |
| 01/24/2024 | 20:12:01 | 78 | 2.0 | 12.37 | 35.1 | 0 | Start Displacement |
| 01/24/2024 | 20:12:03 | 75 | 2.0 | 12.36 | 35.2 | 0 | Displace with OBM. |
| 01/24/2024 | 20:13:31 | 66 | 2.0 | 12.14 | 38.2 | 0 | |
| 01/24/2024 | 20:15:01 | 10 | 1.4 | 12.46 | 41.4 | 0 | |
| 01/24/2024 | 20:16:31 | 7 | 0.1 | 12.65 | 41.6 | 0 | |
| 01/24/2024 | 20:18:01 | 7 | 0.1 | 12.65 | 41.7 | 0 | |
| 01/24/2024 | 20:19:31 | 7 | 0.1 | 12.65 | 41.8 | 0 | |
| 01/24/2024 | 20:21:01 | 95 | 2.3 | 10.51 | 42.5 | 0 | |
| 01/24/2024 | 20:22:31 | 404 | 5.5 | 9.77 | 49.7 | 0 | |
| 01/24/2024 | 20:24:01 | 382 | 5.5 | 9.69 | 57.9 | 0 | |
| 01/24/2024 | 20:25:31 | 383 | 5.5 | 9.71 | 66.0 | 0 | |
| 01/24/2024 | 20:27:01 | 372 | 5.5 | 9.69 | 74.3 | 0 | |
| 01/24/2024 | 20:28:31 | 385 | 5.5 | 9.70 | 82.6 | 0 | |
| 01/24/2024 | 20:30:01 | 378 | 5.5 | 9.69 | 90.8 | 0 | |
| 01/24/2024 | 20:31:31 | 383 | 5.5 | 9.69 | 99.1 | 0 | |
| 01/24/2024 | 20:33:01 | 179 | 3.5 | 9.70 | 106.7 | 0 | |
| 01/24/2024 | 20:34:31 | 79 | 2.1 | 9.67 | 111.5 | 0 | |
| 01/24/2024 | 20:36:01 | 74 | 1.3 | 9.68 | 113.9 | 0 | |
| 01/24/2024 | 20:36:35 | 74 | 1.0 | 9.68 | 114.6 | 0 | End Displacement |
| 01/24/2024 | 20:36:37 | 74 | 1.0 | 9.68 | 114.6 | 0 | Final displacement was 73.1bbls for balance. |
| 01/24/2024 | 20:36:42 | 16 | 0.1 | 9.68 | 114.6 | 0 | End Job |
| 01/24/2024 | 20:36:43 | 15 | 0.0 | 9.68 | 114.6 | 0 | Turn over to rig to pull out of cement. |
| 01/24/2024 | 20:37:31 | 11 | 0.0 | 9.68 | 114.6 | 0 | |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 CYPRESS M-2 | | Jan/24/2024 | TALLGRASS ENERGY | EQX9-00083 |

# Post Job Summary

| Average Pump Rates, bbl/min | | | | Volume of Fluid Injected, bbl | | | |
|---|---|---|---|---|---|---|---|
| Slurry | N2 | Mud | Maximum Rate | Total Slurry | Mud | Spacer | N2 |
| 2.6 | | | 21.1 | 15.8 | 0.0 | 25.0 | |

| Treating Pressure Summary, psi | | | | | Breakdown Fluid | | |
|---|---|---|---|---|---|---|---|
| Maximum | Final | Average | Bump Plug to | Breakdown | Type | Volume | Density |
| 2887 | 19 | 191 | | | | bbl | lb/gal |

| Avg. N2 Percent | Designed Slurry Volume | Displacement | Mix Water Temp | | | |
|---|---|---|---|---|---|---|
| % | 15.5 bbl | 73.1 bbl | 60 degF | Cement Circulated to Surface? ☐ | Volume | bbl |
| | | | | Washed Thru Perfs ☐ | To | ft |

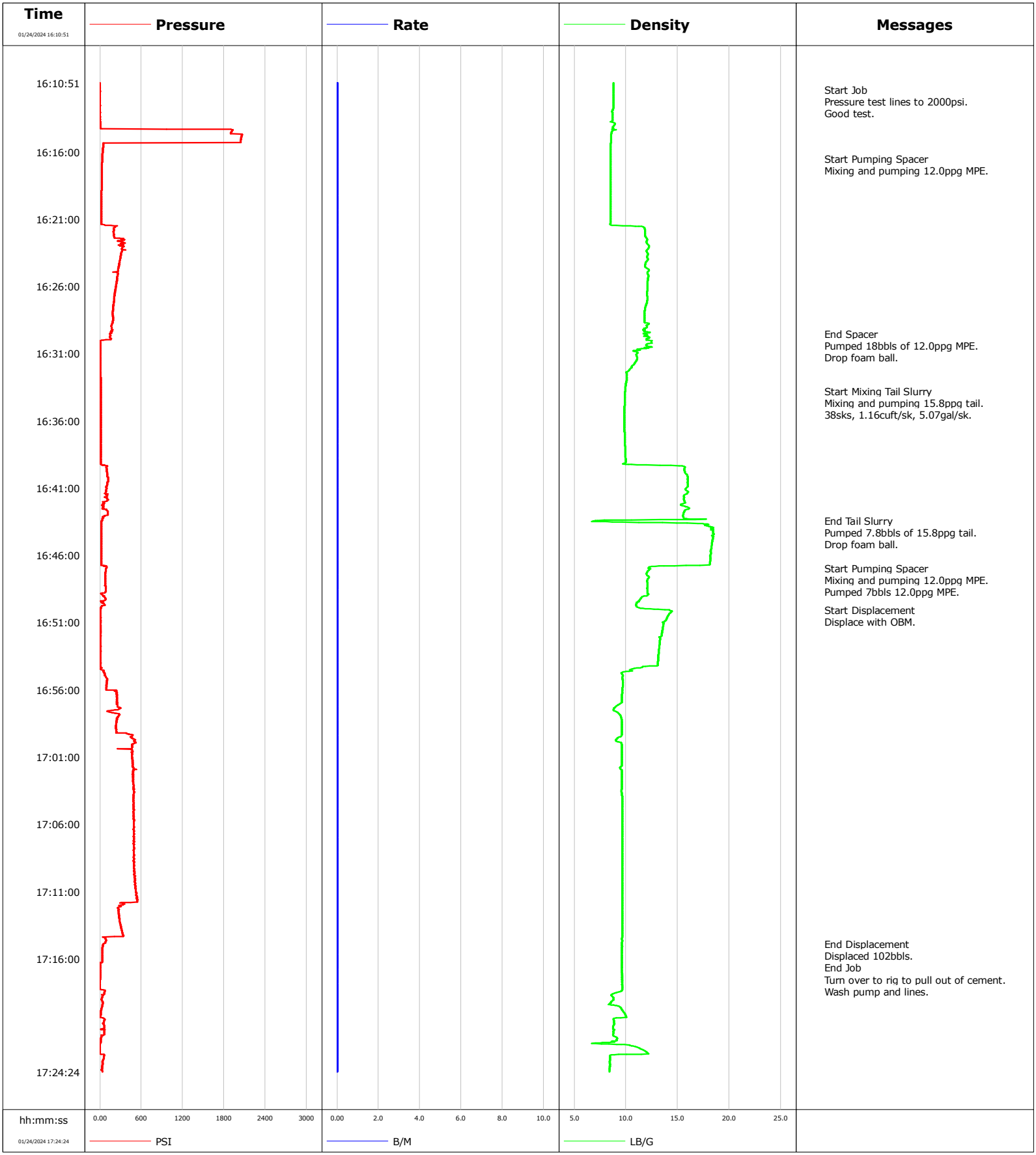
| Customer or Authorized Representative | Schlumberger Supervisor | Circulation Lost | Job Completed |
|---|---|---|---|
| | JEFFREY PATTERSON | ☐ | ☒ |
| | | - | - |

# Schlumberger

# Cementing Job Report



| | | | |
|---|---|---|---|
| **Well** | CYPRESS M-2 | **Client** | TALLGRASS ENERGY |
| **Field** | | **SIR No.** | EWQX9-00083 |
| **Engineer** | JEFFREY PATTERSON | **Job Type** | PLUG 4 |
| **Country** | United States | **Job Date** | 01-24-2024 |



Schlumberger

# Cementing Service Report

| Customer | Job Number |
|---|---|
| TALLGRASS ENERGY | EWQX9-00083 |

| Well | Location (legal) | Schlumberger Location | Job Start |
|---|---|---|---|
| CYPRESS M-2 M-2 | | WINDSOR | Jan/24/2024 |

| Field | Formation Name/Type | Deviation | Bit Size | Well MD | Well TVD |
|---|---|---|---|---|---|
| | | deg | in | 6742.0 ft | ft |

| County | State/Province | BHP | BHST | BHCT | Pore Press. Gradient |
|---|---|---|---|---|---|
| LARAMIE | Wyoming | psi | degF | degF | lb/gal |

| Well Master | API/UWI |
|---|---|
| 0067006788 | 49-021-29598-00-00 |

| Rig Name | Drilled For | Service Via |
|---|---|---|
| TRUE 38 | Injection (Gas) | Land |

| Offshore Zone | Well Class | Well Type |
|---|---|---|
| | New | Exploration |

| Drilling Fluid Type | Max. Density | Plastic Viscosity |
|---|---|---|
| | lb/gal | cP |

| Service Line | Job Type |
|---|---|
| Cementing | PLUG 4 |

| Max. Allowed Tub. Press | Max. Allowed Ann. Press | WH Connection |
|---|---|---|
| psi | psi | 4 1/2" IF DP pin |

**Service Instructions**

38SKS, 1.16CUFT/SK, 5.07CUFT/SK= 7.6BBLS OF 15.8PPG TAIL.

**Casing/Liner**

| Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|
| | | | | |
| | | | | |

**Tubing/Drill Pipe**

| T/D | Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|---|
| D | 6742.0 | 5.0 | 19.5 | | |
| | 0.0 | 0.0 | 0.0 | | |

**Perforations/Open Hole**

| Top, ft | Bottom, ft | shot/ft | No. of Shots | Total Interval |
|---|---|---|---|---|
| ft | ft | | | ft |
| ft | ft | | | Diameter |
| ft | ft | | | in |

| Treat Down | Displacement | Packer Type | Packer Depth |
|---|---|---|---|
| Drill Pipe | 100.0 bbl | | ft |

| Tubing Vol. | Casing Vol. | Annular Vol. | Openhole Vol. |
|---|---|---|---|
| 111.0 bbl | bbl | bbl | bbl |

| Casing/Tubing Secured | 1 Hole Vol. Circulated prior to Cement |
|---|---|
| X | X |

| Lift Pressure | | |
|---|---|---|
| psi | | |

| Pipe Rotated | Pipe Reciprocated |
|---|---|
| ☐ | ☐ |

| No. Centralizers | Top Plugs | Bottom Plugs |
|---|---|---|
| | | |

| Cement Head Type |
|---|
| |

| Job Scheduled For | Arrived on Location | Leave Location |
|---|---|---|
| Jan/24/2024 16:00 | Jan/24/2024 16:00 | Jan/24/2024 18:00 |

| Casing Tools | | Squeeze Job | |
|---|---|---|---|
| Shoe Type | | Squeeze Type | |
| Shoe Depth | ft | Tool Type | |
| Stage Tool Type | | Tool Depth | ft |
| Stage Tool Depth | ft | Tail Pipe Size | in |
| Collar Type | | Tail Pipe Depth | ft |
| Collar Depth | ft | Sqz. Total Vol. | bbl |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 16:10:51 | -1 | 0.4 | 8.76 | 2.0 | 0 | Started Acquisition |
| 01/24/2024 | 16:11:21 | -1 | 0.4 | 8.76 | 2.2 | 0 | Start Job |
| 01/24/2024 | 16:11:22 | -0 | 0.4 | 8.76 | 2.3 | 0 | Pressure test lines to 2000psi. |
| 01/24/2024 | 16:11:23 | 0 | 0.4 | 8.76 | 2.3 | 0 | Good test. |
| 01/24/2024 | 16:12:21 | -0 | 0.4 | 8.77 | 0.2 | 0 | |
| 01/24/2024 | 16:13:51 | 1 | 0.7 | 8.89 | 0.3 | 0 | |
| 01/24/2024 | 16:15:21 | 47 | 0.1 | 8.52 | 0.3 | 0 | |
| 01/24/2024 | 16:16:31 | 31 | 0.1 | 8.51 | 0.4 | 0 | Start Pumping Spacer |
| 01/24/2024 | 16:16:32 | 31 | 0.1 | 8.51 | 0.4 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/24/2024 | 16:16:51 | 28 | 0.1 | 8.51 | 0.4 | 0 | |
| 01/24/2024 | 16:18:21 | 22 | 0.1 | 8.51 | 0.6 | 0 | |
| 01/24/2024 | 16:19:51 | 20 | 0.1 | 8.50 | 0.8 | 0 | |
| 01/24/2024 | 16:21:21 | 19 | 0.3 | 8.49 | 1.0 | 0 | |
| 01/24/2024 | 16:22:51 | 331 | 2.2 | 12.09 | 3.1 | 0 | |
| 01/24/2024 | 16:24:21 | 279 | 2.3 | 11.86 | 6.5 | 0 | |
| 01/24/2024 | 16:25:51 | 234 | 2.3 | 12.07 | 9.9 | 0 | |
| 01/24/2024 | 16:27:21 | 195 | 2.3 | 11.96 | 13.3 | 0 | |
| 01/24/2024 | 16:28:51 | 165 | 2.4 | 12.09 | 16.8 | 0 | |
| 01/24/2024 | 16:29:31 | 143 | 2.4 | 11.70 | 18.4 | 0 | End Spacer |
| 01/24/2024 | 16:29:34 | 153 | 2.3 | 11.95 | 18.5 | 0 | Pumped 18bbls of 12.0ppg MPE. |
| 01/24/2024 | 16:29:39 | 149 | 2.4 | 12.01 | 18.7 | 0 | Drop foam ball. |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/24/2024 | TALLGRASS ENERGY | EWQX9-00083 |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 16:31:51 | 6 | 0.0 | 10.68 | 19.6 | 0 | |
| 01/24/2024 | 16:33:47 | 12 | 0.0 | 9.91 | 19.6 | 0 | Start Mixing Tail Slurry |
| 01/24/2024 | 16:33:48 | 12 | 0.0 | 9.91 | 19.6 | 0 | Mixing and pumping 15.8ppg tail. |
| 01/24/2024 | 16:33:49 | 11 | 0.0 | 9.91 | 19.6 | 0 | 38sks, 1.16cuft/sk, 5.07gal/sk. |
| 01/24/2024 | 16:34:51 | 10 | 0.0 | 9.86 | 19.7 | 0 | |
| 01/24/2024 | 16:36:21 | 10 | 0.1 | 9.84 | 19.7 | 0 | |
| 01/24/2024 | 16:37:51 | 9 | 0.1 | 9.90 | 19.8 | 0 | |
| 01/24/2024 | 16:39:21 | 96 | 2.8 | 15.43 | 20.0 | 0 | |
| 01/24/2024 | 16:40:51 | 93 | 1.6 | 15.98 | 23.3 | 0 | |
| 01/24/2024 | 16:42:21 | 62 | 1.3 | 15.72 | 25.6 | 0 | |
| 01/24/2024 | 16:43:25 | 35 | 0.0 | 7.08 | 27.4 | 0 | End Tail Slurry |
| 01/24/2024 | 16:43:26 | 31 | 0.0 | 6.85 | 27.4 | 0 | Pumped 7.8bbls of 15.8ppg tail. |
| 01/24/2024 | 16:43:29 | 19 | 0.0 | 7.57 | 27.4 | 0 | Drop foam ball. |
| 01/24/2024 | 16:43:51 | 18 | 0.0 | 18.09 | 27.4 | 0 | |
| 01/24/2024 | 16:45:21 | 17 | 0.0 | 18.27 | 27.4 | 0 | |
| 01/24/2024 | 16:46:51 | 94 | 1.8 | 12.34 | 27.5 | 0 | |
| 01/24/2024 | 16:46:55 | 98 | 2.1 | 12.21 | 27.6 | 0 | Start Pumping Spacer |
| 01/24/2024 | 16:46:57 | 87 | 1.9 | 12.17 | 27.7 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/24/2024 | 16:48:21 | 83 | 2.5 | 12.05 | 30.9 | 0 | |
| 01/24/2024 | 16:49:51 | 19 | 1.2 | 11.13 | 34.0 | 0 | |
| 01/24/2024 | 16:50:02 | 3 | 0.0 | 13.80 | 34.1 | 0 | Start Displacement |
| 01/24/2024 | 16:50:04 | 3 | 0.0 | 14.28 | 34.1 | 0 | Displace with OBM. |
| 01/24/2024 | 16:51:21 | 7 | 0.0 | 13.57 | 34.1 | 0 | |
| 01/24/2024 | 16:52:51 | 7 | 0.0 | 13.21 | 34.1 | 0 | |
| 01/24/2024 | 16:54:21 | 29 | 0.7 | 11.41 | 34.3 | 0 | |
| 01/24/2024 | 16:55:51 | 91 | 2.3 | 9.66 | 37.6 | 0 | |
| 01/24/2024 | 16:57:21 | 301 | 4.2 | 8.85 | 43.6 | 0 | |
| 01/24/2024 | 16:58:51 | 241 | 4.2 | 9.60 | 49.9 | 0 | |
| 01/24/2024 | 17:00:21 | 467 | 5.5 | 9.60 | 57.6 | 0 | |
| 01/24/2024 | 17:01:51 | 494 | 5.5 | 9.46 | 65.8 | 0 | |
| 01/24/2024 | 17:03:21 | 484 | 5.5 | 9.57 | 74.0 | 0 | |
| 01/24/2024 | 17:04:51 | 490 | 5.5 | 9.63 | 82.2 | 0 | |
| 01/24/2024 | 17:06:21 | 485 | 5.5 | 9.63 | 90.4 | 0 | |
| 01/24/2024 | 17:07:51 | 489 | 5.5 | 9.63 | 98.6 | 0 | |
| 01/24/2024 | 17:09:21 | 498 | 5.5 | 9.63 | 106.9 | 0 | |
| 01/24/2024 | 17:10:51 | 516 | 5.5 | 9.63 | 115.1 | 0 | |
| 01/24/2024 | 17:12:21 | 267 | 3.4 | 9.63 | 122.4 | 0 | |
| 01/24/2024 | 17:13:51 | 312 | 3.4 | 9.62 | 127.5 | 0 | |
| 01/24/2024 | 17:14:53 | 51 | 0.0 | 9.62 | 129.6 | 0 | End Displacement |
| 01/24/2024 | 17:14:54 | 48 | 0.0 | 9.62 | 129.6 | 0 | Displaced 102bbls. |
| 01/24/2024 | 17:15:00 | 40 | 0.0 | 9.62 | 129.6 | 0 | End Job |
| 01/24/2024 | 17:15:02 | 39 | 0.0 | 9.62 | 129.6 | 0 | Turn over to rig to pull out of cement. |
| 01/24/2024 | 17:15:21 | 33 | 0.0 | 9.62 | 129.6 | 0 | |
| 01/24/2024 | 17:16:51 | 2 | 0.0 | 9.62 | 129.6 | 0 | |
| 01/24/2024 | 17:18:21 | 69 | 2.3 | 9.61 | 129.6 | 0 | |
| 01/24/2024 | 17:19:51 | 14 | 1.0 | 9.68 | 129.6 | 0 | |
| 01/24/2024 | 17:21:21 | 63 | 2.6 | 8.84 | 129.6 | 0 | |
| 01/24/2024 | 17:22:51 | -1 | 2.1 | 11.84 | 129.6 | 0 | |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/24/2024 | TALLGRASS ENERGY | EWQX9-00083 |

# Post Job Summary

| Average Pump Rates, bbl/min | | | | Volume of Fluid Injected, bbl | | | |
|---|---|---|---|---|---|---|---|
| Slurry | N2 | Mud | Maximum Rate | Total Slurry | Mud | Spacer | N2 |
| 2.3 | | | 5.5 | 7.8 | 0.0 | 25.0 | |

| Treating Pressure Summary, psi | | | | | Breakdown Fluid | | |
|---|---|---|---|---|---|---|---|
| Maximum | Final | Average | Bump Plug to | Breakdown | Type | Volume | Density |
| 2065 | 21 | 188 | | | | bbl | lb/gal |

| Avg. N2 Percent | Designed Slurry Volume | Displacement | Mix Water Temp | | |
|---|---|---|---|---|---|
| % | 7.6 bbl | 102.0 bbl | 60 degF | Cement Circulated to Surface? ☐ | Volume bbl |
| | | | | Washed Thru Perfs ☐ | To ft |

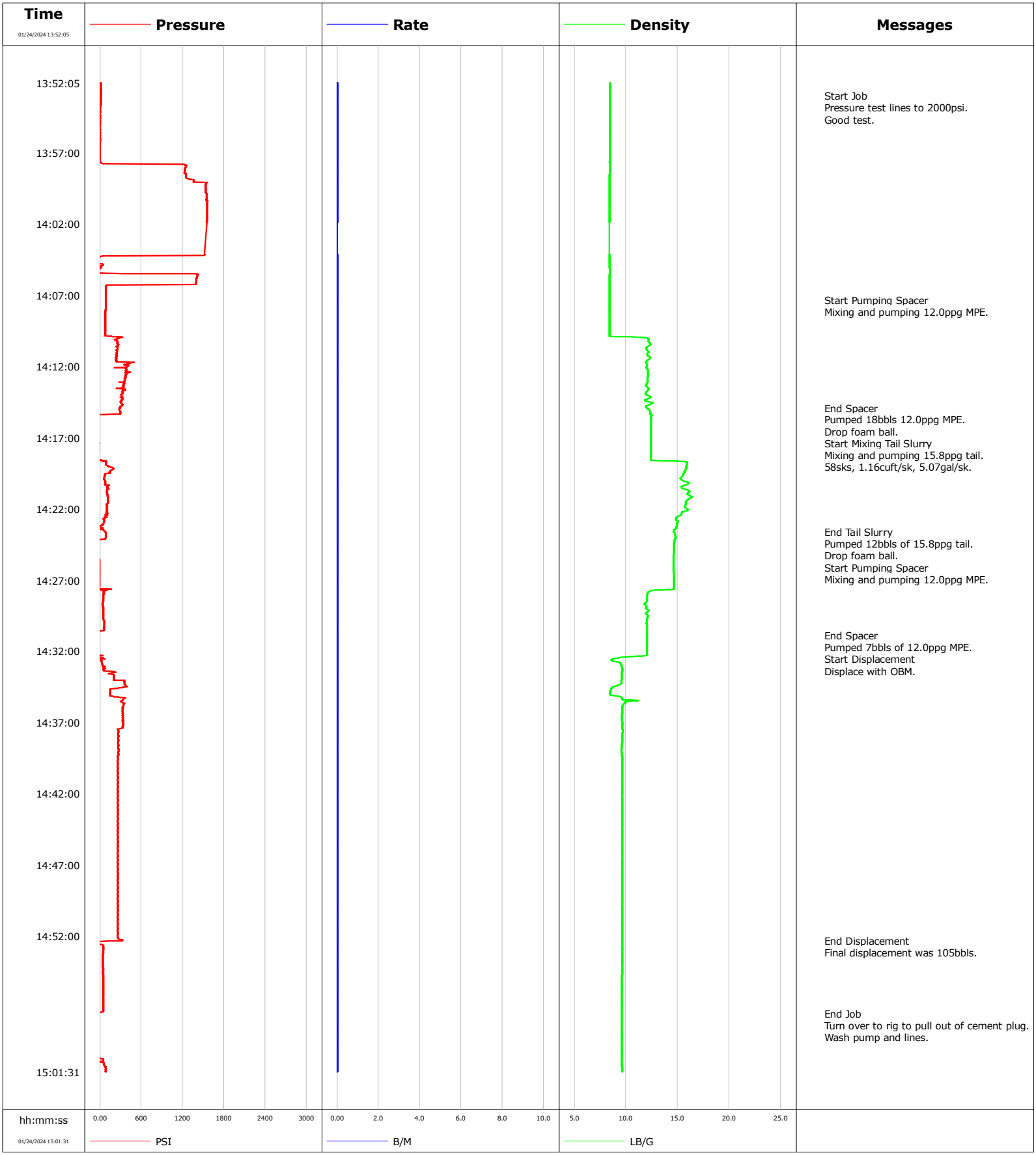
| Customer or Authorized Representative | Schlumberger Supervisor | Circulation Lost ☐ | Job Completed ☐ |
|---|---|---|---|
| | JEFFREY PATTERSON | - | - |

# Schlumberger

# Cementing Job Report



| | | | |
|---|---|---|---|
| **Well** | CYPRESS M-2 | **Client** | TALLGRASS ENERGY |
| **Field** | | **SIR No.** | EQX9-00083 |
| **Engineer** | JEFFREY PATTERSON | **Job Type** | PLUG 3 |
| **Country** | United States | **Job Date** | 01-24-2024 |



Schlumberger

# Cementing Service Report

| Customer | Job Number |
|---|---|
| TALLGRASS ENERGY | EQX9-00083 |

| Well | Location (legal) | Schlumberger Location | Job Start |
|---|---|---|---|
| CYPRESS M-2 M-2 | | WINDSOR | Jan/24/2024 |

| Field | Formation Name/Type | Deviation | Bit Size | Well MD | Well TVD |
|---|---|---|---|---|---|
| | | deg | in | 7152.0 ft | ft |

| County | State/Province | BHP | BHST | BHCT | Pore Press. Gradient |
|---|---|---|---|---|---|
| LARAMIE | Wyoming | psi | degF | degF | lb/gal |

| Well Master | API/UWI |
|---|---|
| 0067006788 | 49-021-29598-00-00 |

| Rig Name | Drilled For | Service Via |
|---|---|---|
| TRUE 38 | Injection (Gas) | Land |

| Offshore Zone | Well Class | Well Type |
|---|---|---|
| | New | Exploration |

| Drilling Fluid Type | Max. Density | Plastic Viscosity |
|---|---|---|
| | lb/gal | cP |

| Service Line | Job Type |
|---|---|
| Cementing | PLUG 3 |

| Max. Allowed Tub. Press | Max. Allowed Ann. Press | WH Connection |
|---|---|---|
| psi | psi | 4 1/2" IF DP pin |

**Service Instructions**

58SKS, 1.16CUFT/SK, 5.07GAL/SK = 12BBLS OF 15.8PPG TAIL.

**Casing/Liner**

| Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|
| | | | | |
| | | | | |

**Tubing/Drill Pipe**

| T/D | Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|---|
| D | 7152.0 | 5.0 | 19.5 | | |
| | 0.0 | 0.0 | 0.0 | | |

**Perforations/Open Hole**

| Top, ft | Bottom, ft | shot/ft | No. of Shots | Total Interval |
|---|---|---|---|---|
| ft | ft | | | ft |
| ft | ft | | | Diameter |
| ft | ft | | | in |

| Treat Down | Displacement | Packer Type | Packer Depth |
|---|---|---|---|
| Drill Pipe | 110.0 bbl | | ft |

| Tubing Vol. | Casing Vol. | Annular Vol. | Openhole Vol. |
|---|---|---|---|
| 117.0 bbl | bbl | bbl | bbl |

| Casing/Tubing Secured | 1 Hole Vol. Circulated prior to Cement |
|---|---|
| X | X |

| Lift Pressure | Pipe Rotated | Pipe Reciprocated |
|---|---|---|
| psi | ☐ | ☐ |

| No. Centralizers | Top Plugs | Bottom Plugs |
|---|---|---|
| | | |

| Cement Head Type |
|---|
| |

| Job Scheduled For | Arrived on Location | Leave Location |
|---|---|---|
| Jan/24/2024 13:00 | Jan/24/2024 13:00 | Jan/24/2024 15:00 |

| Casing Tools | | Squeeze Job | |
|---|---|---|---|
| Shoe Type | | Squeeze Type | |
| Shoe Depth | ft | Tool Type | |
| Stage Tool Type | | Tool Depth | ft |
| Stage Tool Depth | ft | Tail Pipe Size | in |
| Collar Type | | Tail Pipe Depth | ft |
| Collar Depth | ft | Sqz. Total Vol. | bbl |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 13:52:05 | 14 | 0.0 | 8.46 | 217.4 | 0 | Started Acquisition |
| 01/24/2024 | 13:53:00 | 13 | 0.0 | 8.46 | 217.4 | 0 | Start Job |
| 01/24/2024 | 13:53:02 | 13 | 0.0 | 8.46 | 217.4 | 0 | Pressure test lines to 2000psi. |
| 01/24/2024 | 13:53:35 | 13 | 0.0 | 8.46 | 0.0 | 0 | |
| 01/24/2024 | 13:55:05 | 0 | 0.0 | 8.46 | 0.1 | 0 | |
| 01/24/2024 | 13:56:35 | -1 | 0.0 | 8.46 | 0.1 | 0 | |
| 01/24/2024 | 13:58:05 | 1237 | 0.0 | 8.44 | 0.4 | 0 | |
| 01/24/2024 | 13:59:35 | 1536 | 0.0 | 8.42 | 0.5 | 0 | |
| 01/24/2024 | 14:01:05 | 1554 | 0.0 | 8.41 | 0.5 | 0 | |
| 01/24/2024 | 14:05:35 | 1420 | 0.0 | 8.42 | 0.0 | 0 | |
| 01/24/2024 | 14:07:05 | 82 | 0.0 | 8.42 | 0.0 | 0 | |
| 01/24/2024 | 14:07:19 | 80 | 0.0 | 8.42 | 0.0 | 0 | Start Pumping Spacer |
| 01/24/2024 | 14:07:21 | 80 | 0.0 | 8.42 | 0.0 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/24/2024 | 14:08:35 | 77 | 0.0 | 8.42 | 0.1 | 0 | |
| 01/24/2024 | 14:10:05 | 244 | 2.3 | 12.16 | 0.5 | 0 | |
| 01/24/2024 | 14:11:35 | 243 | 2.3 | 12.06 | 3.9 | 0 | |
| 01/24/2024 | 14:13:05 | 356 | 4.2 | 12.09 | 10.0 | 0 | |
| 01/24/2024 | 14:14:35 | 306 | 4.2 | 12.55 | 16.2 | 0 | |
| 01/24/2024 | 14:14:53 | 292 | 4.2 | 11.98 | 17.5 | 0 | End Spacer |
| 01/24/2024 | 14:14:55 | 286 | 4.2 | 12.02 | 17.6 | 0 | Pumped 18bbls 12.0ppg MPE. |
| 01/24/2024 | 14:14:57 | 286 | 4.2 | 12.07 | 17.8 | 0 | Drop foam ball. |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/24/2024 | TALLGRASS ENERGY | EQX9-00083 |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 14:15:03 | 286 | 4.2 | 12.27 | 18.2 | 0 | Mixing and pumping 15.8ppg tail. |
| 01/24/2024 | 14:16:05 | -23 | 0.0 | 12.40 | 19.7 | 0 | |
| 01/24/2024 | 14:17:35 | -14 | 0.0 | 12.39 | 19.7 | 0 | |
| 01/24/2024 | 14:19:05 | 158 | 2.3 | 15.84 | 20.8 | 0 | |
| 01/24/2024 | 14:20:35 | 105 | 2.3 | 15.55 | 23.8 | 0 | |
| 01/24/2024 | 14:22:05 | 104 | 2.3 | 16.01 | 27.3 | 0 | |
| 01/24/2024 | 14:23:35 | 72 | 2.1 | 14.60 | 30.3 | 0 | |
| 01/24/2024 | 14:23:37 | 77 | 2.2 | 14.63 | 30.4 | 0 | End Tail Slurry |
| 01/24/2024 | 14:23:39 | 79 | 2.3 | 14.67 | 30.5 | 0 | Pumped 12bbls of 15.8ppg tail. |
| 01/24/2024 | 14:23:42 | 81 | 2.4 | 14.73 | 30.6 | 0 | Drop foam ball. |
| 01/24/2024 | 14:23:50 | 80 | 2.5 | 14.74 | 30.9 | 0 | Start Pumping Spacer |
| 01/24/2024 | 14:23:52 | 81 | 2.5 | 14.76 | 31.0 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/24/2024 | 14:25:05 | -21 | 0.0 | 14.63 | 31.8 | 0 | |
| 01/24/2024 | 14:26:35 | -13 | 0.0 | 14.62 | 31.8 | 0 | |
| 01/24/2024 | 14:28:05 | 48 | 2.4 | 12.03 | 32.7 | 0 | |
| 01/24/2024 | 14:29:35 | 48 | 2.4 | 12.11 | 36.4 | 0 | |
| 01/24/2024 | 14:30:53 | -23 | 0.0 | 12.03 | 39.1 | 0 | End Spacer |
| 01/24/2024 | 14:30:54 | -23 | 0.0 | 12.03 | 39.1 | 0 | Pumped 7bbls of 12.0ppg MPE. |
| 01/24/2024 | 14:30:59 | -22 | 0.0 | 12.03 | 39.1 | 0 | Start Displacement |
| 01/24/2024 | 14:31:00 | -23 | 0.0 | 12.03 | 39.1 | 0 | Displace with OBM. |
| 01/24/2024 | 14:31:05 | -23 | 0.0 | 12.03 | 39.1 | 0 | |
| 01/24/2024 | 14:32:35 | -23 | 1.9 | 8.62 | 39.4 | 0 | |
| 01/24/2024 | 14:34:05 | 351 | 5.3 | 9.56 | 44.1 | 0 | |
| 01/24/2024 | 14:35:35 | 327 | 5.5 | 9.90 | 52.4 | 0 | |
| 01/24/2024 | 14:37:05 | 344 | 5.5 | 9.67 | 60.7 | 0 | |
| 01/24/2024 | 14:38:35 | 270 | 4.9 | 9.61 | 68.3 | 0 | |
| 01/24/2024 | 14:40:05 | 253 | 4.9 | 9.63 | 75.7 | 0 | |
| 01/24/2024 | 14:41:35 | 256 | 4.9 | 9.64 | 83.0 | 0 | |
| 01/24/2024 | 14:43:05 | 262 | 4.9 | 9.64 | 90.4 | 0 | |
| 01/24/2024 | 14:44:35 | 252 | 4.9 | 9.64 | 97.8 | 0 | |
| 01/24/2024 | 14:46:05 | 255 | 4.9 | 9.64 | 105.2 | 0 | |
| 01/24/2024 | 14:47:35 | 264 | 4.9 | 9.64 | 112.6 | 0 | |
| 01/24/2024 | 14:49:05 | 253 | 4.9 | 9.64 | 120.0 | 0 | |
| 01/24/2024 | 14:50:35 | 256 | 4.9 | 9.64 | 127.4 | 0 | |
| 01/24/2024 | 14:52:05 | 263 | 4.9 | 9.63 | 134.8 | 0 | |
| 01/24/2024 | 14:52:18 | 326 | 4.9 | 9.64 | 135.8 | 0 | End Displacement |
| 01/24/2024 | 14:52:19 | 316 | 4.9 | 9.63 | 135.9 | 0 | Final displacement was 105bbls. |
| 01/24/2024 | 14:53:35 | 42 | 2.2 | 9.63 | 138.4 | 0 | |
| 01/24/2024 | 14:55:05 | 45 | 1.6 | 9.61 | 141.3 | 0 | |
| 01/24/2024 | 14:56:35 | 45 | 1.1 | 9.61 | 143.3 | 0 | |
| 01/24/2024 | 14:57:24 | -19 | 0.1 | 9.61 | 144.0 | 0 | End Job |
| 01/24/2024 | 14:57:25 | -17 | 0.0 | 9.61 | 144.0 | 0 | Turn over to rig to pull out of cement plug. |
| 01/24/2024 | 14:57:26 | -19 | 0.0 | 9.61 | 144.0 | 0 | Wash pump and lines. |
| 01/24/2024 | 14:58:05 | -22 | 0.0 | 9.61 | 144.0 | 0 | |
| 01/24/2024 | 14:59:35 | -21 | 0.0 | 9.61 | 144.0 | 0 | |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/24/2024 | TALLGRASS ENERGY | EQX9-00083 |

# Post Job Summary

| Average Pump Rates, bbl/min | | | | Volume of Fluid Injected, bbl | | | |
|---|---|---|---|---|---|---|---|
| Slurry | N2 | Mud | Maximum Rate | Total Slurry | Mud | Spacer | N2 |
| 2.6 | | | 5.8 | 12.0 | 0.0 | 25.0 | |

| Treating Pressure Summary, psi | | | | | Breakdown Fluid | | |
|---|---|---|---|---|---|---|---|
| Maximum | Final | Average | Bump Plug to | Breakdown | Type | Volume | Density |
| 1560 | 90 | 300 | | | | bbl | lb/gal |

| Avg. N2 Percent | Designed Slurry Volume | Displacement | Mix Water Temp | | |
|---|---|---|---|---|---|
| % | 12.0 bbl | 105.0 bbl | 60 degF | Cement Circulated to Surface? ☐ | Volume bbl |
| | | | | Washed Thru Perfs ☐ | To ft |

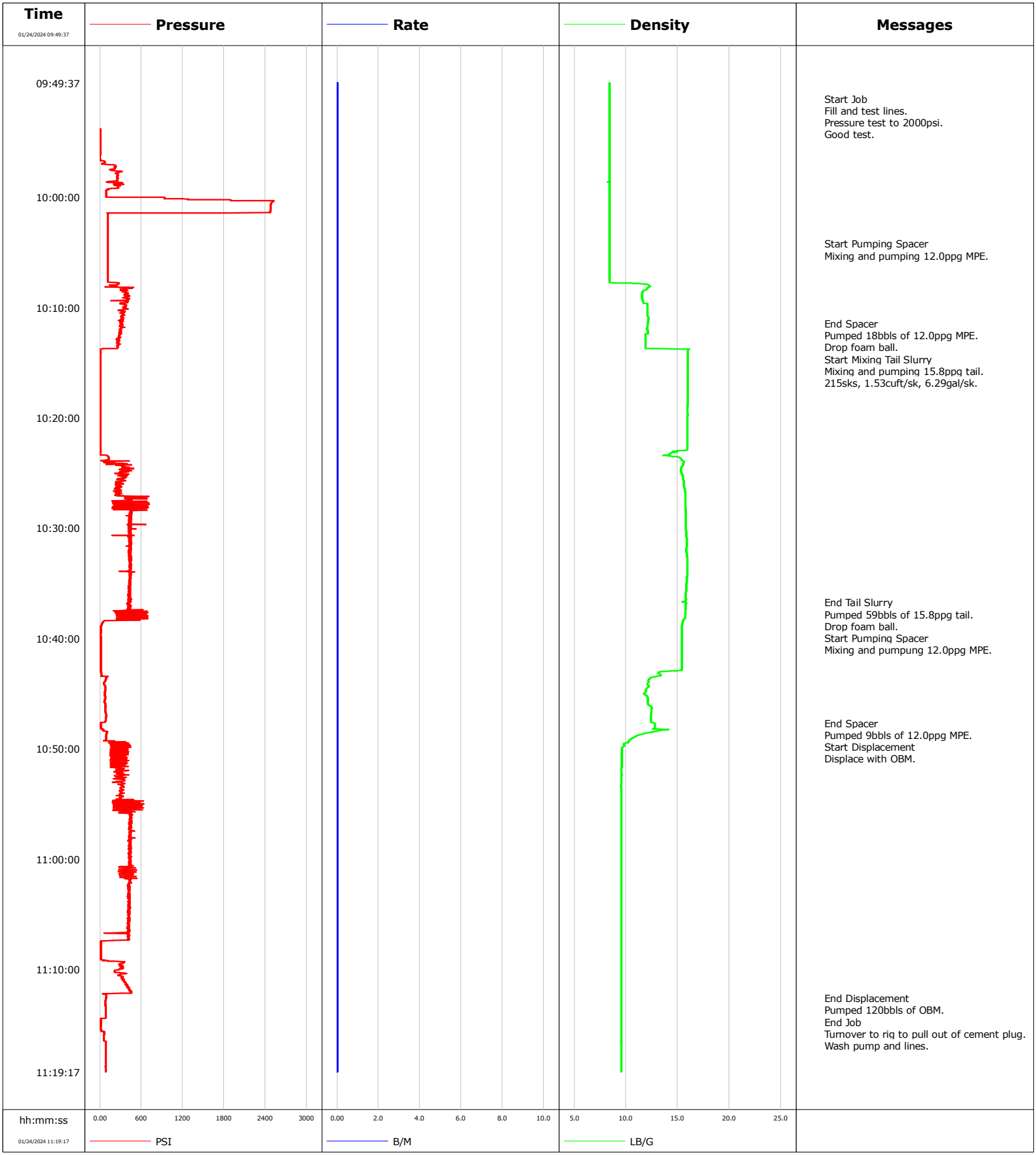
| Customer or Authorized Representative | Schlumberger Supervisor | Circulation Lost | Job Completed |
|---|---|---|---|
| | JEFFREY PATTERSON | ☐ | ☒ |
| | | - | - |

# Schlumberger

# Cementing Job Report



| | | | |
|---|---|---|---|
| **Well** | CYPRESS M-2 | **Client** | TALLGRASS ENERGY |
| **Field** | | **SIR No.** | EQX9-00083 |
| **Engineer** | JEFFREY PATTERSON | **Job Type** | PLUG 7 |
| **Country** | United States | **Job Date** | 01-24-2024 |



# Schlumberger Cementing Service Report

| Customer | Job Number |
|---|---|
| TALLGRASS ENERGY | EQX9-00083 |

| Well | Location (legal) | Schlumberger Location | Job Start |
|---|---|---|---|
| CYPRESS M-2 M-2 | | WINDSOR | Jan/24/2024 |

| Field | Formation Name/Type | Deviation | Bit Size | Well MD | Well TVD |
|---|---|---|---|---|---|
| | | deg | in | 8311.0 ft | ft |

| County | State/Province | BHP | BHST | BHCT | Pore Press. Gradient |
|---|---|---|---|---|---|
| LARAMIE | Wyoming | psi | 263 degF | 211 degF | lb/gal |

| Well Master | API/UWI |
|---|---|
| 0067006788 | 49-021-29598-00-00 |

| Rig Name | Drilled For | Service Via |
|---|---|---|
| TRUE 38 | Gas Injector | Land |

| Offshore Zone | Well Class | Well Type |
|---|---|---|
| | New | Exploration |

| Drilling Fluid Type | Max. Density | Plastic Viscosity |
|---|---|---|
| | lb/gal | cP |

| Service Line | Job Type |
|---|---|
| Cementing | PLUG 7 |

| Max. Allowed Tub. Press | Max. Allowed Ann. Press | WH Connection |
|---|---|---|
| psi | psi | 4 1/2" IF DP pin |

**Service Instructions**

215SKS, 1.53CUFT/SK, 6.29GAL/SK= 59BBLS OF 15.8PPG TAIL.

**Casing/Liner**

| Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|
| | | | | |
| | | | | |

**Tubing/Drill Pipe**

| T/D | Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|---|
| D | 8311.0 | 5.0 | 19.5 | | |
| | 0.0 | 0.0 | 0.0 | | |

**Perforations/Open Hole**

| Top, ft | Bottom, ft | shot/ft | No. of Shots | Total Interval |
|---|---|---|---|---|
| ft | ft | | | ft |
| ft | ft | | | Diameter |
| ft | ft | | | in |

| Treat Down | Displacement | Packer Type | Packer Depth |
|---|---|---|---|
| Drill Pipe | 120.0 bbl | | ft |

| Tubing Vol. | Casing Vol. | Annular Vol. | Openhole Vol. |
|---|---|---|---|
| 127.0 bbl | bbl | bbl | bbl |

| Casing/Tubing Secured | 1 Hole Vol. Circulated prior to Cement | Casing Tools | Squeeze Job |
|---|---|---|---|
| X | X | | |

| Lift Pressure | Shoe Type | Squeeze Type |
|---|---|---|
| psi | | |

| Pipe Rotated | Pipe Reciprocated | Shoe Depth | Tool Type |
|---|---|---|---|
| ☐ | ☐ | ft | |

| No. Centralizers | Top Plugs | Bottom Plugs | Stage Tool Type | Tool Depth |
|---|---|---|---|---|
| | | | | ft |

| Cement Head Type | Stage Tool Depth | Tail Pipe Size |
|---|---|---|
| | ft | in |

| Job Scheduled For | Arrived on Location | Leave Location | Collar Type | Tail Pipe Depth |
|---|---|---|---|---|
| Jan/24/2024 10:00 | Jan/24/2024 10:00 | Jan/24/2024 12:00 | | ft |

| Collar Depth | Sqz. Total Vol. |
|---|---|
| ft | bbl |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 09:49:37 | -40 | 0.0 | 8.41 | 0.0 | 0 | Started Acquisition |
| 01/24/2024 | 09:51:05 | -40 | 0.0 | 8.41 | 0.0 | 0 | Start Job |
| 01/24/2024 | 09:51:07 | -39 | 0.0 | 8.41 | 0.0 | 0 | Fill and test lines. |
| 01/24/2024 | 09:52:37 | -39 | 0.0 | 8.41 | 0.0 | 0 | |
| 01/24/2024 | 09:54:07 | 1 | 0.0 | 8.41 | 0.0 | 0 | |
| 01/24/2024 | 09:55:37 | 1 | 0.0 | 8.41 | 0.0 | 0 | |
| 01/24/2024 | 09:57:07 | 229 | 1.5 | 8.40 | 0.6 | 0 | |
| 01/24/2024 | 09:58:37 | 99 | 2.6 | 8.22 | 3.5 | 0 | |
| 01/24/2024 | 10:01:37 | 110 | 0.0 | 8.40 | 5.0 | 0 | |
| 01/24/2024 | 10:03:07 | 108 | 0.0 | 8.40 | 5.0 | 0 | |
| 01/24/2024 | 10:04:13 | 109 | 0.0 | 8.40 | 5.0 | 0 | Start Pumping Spacer |
| 01/24/2024 | 10:04:14 | 108 | 0.0 | 8.40 | 5.0 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/24/2024 | 10:04:37 | 109 | 0.0 | 8.40 | 5.0 | 0 | |
| 01/24/2024 | 10:06:07 | 108 | 0.0 | 8.40 | 5.1 | 0 | |
| 01/24/2024 | 10:07:37 | 108 | 0.0 | 8.40 | 5.1 | 0 | |
| 01/24/2024 | 10:09:07 | 355 | 3.3 | 11.56 | 8.8 | 0 | |
| 01/24/2024 | 10:10:37 | 329 | 3.3 | 12.05 | 13.8 | 0 | |
| 01/24/2024 | 10:11:27 | 300 | 3.3 | 12.10 | 16.5 | 0 | End Spacer |
| 01/24/2024 | 10:11:29 | 323 | 3.3 | 12.09 | 16.7 | 0 | Pumped 18bbls of 12.0ppg MPE. |
| 01/24/2024 | 10:11:32 | 313 | 3.3 | 12.09 | 16.8 | 0 | Drop foam ball. |
| 01/24/2024 | 10:11:39 | 308 | 3.3 | 12.10 | 17.2 | 0 | Start Mixing Tail Slurry |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/24/2024 | TALLGRASS ENERGY | EQX9-00083 |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 10:12:07 | 290 | 3.3 | 12.12 | 18.8 | 0 | |
| 01/24/2024 | 10:13:37 | 255 | 3.3 | 11.87 | 23.8 | 0 | |
| 01/24/2024 | 10:15:07 | 1 | 0.0 | 15.98 | 24.3 | 0 | |
| 01/24/2024 | 10:16:37 | 3 | 0.0 | 15.98 | 24.3 | 0 | |
| 01/24/2024 | 10:18:07 | 3 | 0.0 | 15.98 | 24.3 | 0 | |
| 01/24/2024 | 10:19:37 | 4 | 0.0 | 15.95 | 24.3 | 0 | |
| 01/24/2024 | 10:21:07 | 3 | 0.0 | 15.94 | 24.3 | 0 | |
| 01/24/2024 | 10:22:37 | 3 | 0.0 | 15.94 | 24.3 | 0 | |
| 01/24/2024 | 10:24:07 | 95 | 1.4 | 15.54 | 25.6 | 0 | |
| 01/24/2024 | 10:25:37 | 246 | 3.3 | 15.54 | 30.4 | 0 | |
| 01/24/2024 | 10:27:07 | 628 | 4.0 | 15.72 | 35.4 | 0 | |
| 01/24/2024 | 10:28:37 | 432 | 4.6 | 15.80 | 41.7 | 0 | |
| 01/24/2024 | 10:30:07 | 424 | 4.5 | 15.80 | 48.6 | 0 | |
| 01/24/2024 | 10:31:37 | 433 | 4.6 | 15.88 | 55.4 | 0 | |
| 01/24/2024 | 10:33:07 | 446 | 4.6 | 15.92 | 62.2 | 0 | |
| 01/24/2024 | 10:34:37 | 424 | 4.6 | 15.89 | 69.0 | 0 | |
| 01/24/2024 | 10:36:07 | 437 | 4.6 | 15.79 | 75.9 | 0 | |
| 01/24/2024 | 10:36:44 | 405 | 4.6 | 15.73 | 78.8 | 0 | End Tail Slurry |
| 01/24/2024 | 10:36:46 | 429 | 4.6 | 15.81 | 78.9 | 0 | Pumped 59bbls of 15.8ppg tail. |
| 01/24/2024 | 10:36:49 | 401 | 4.6 | 15.83 | 79.1 | 0 | Drop foam ball. |
| 01/24/2024 | 10:36:58 | 434 | 4.6 | 15.77 | 79.8 | 0 | Start Pumping Spacer |
| 01/24/2024 | 10:37:02 | 452 | 4.6 | 15.78 | 80.1 | 0 | Mixing and pumpung 12.0ppg MPE. |
| 01/24/2024 | 10:37:37 | 256 | 4.2 | 15.73 | 82.7 | 0 | |
| 01/24/2024 | 10:39:07 | 9 | 0.0 | 15.41 | 86.1 | 0 | |
| 01/24/2024 | 10:40:37 | 8 | 0.0 | 15.38 | 86.1 | 0 | |
| 01/24/2024 | 10:42:07 | 8 | 0.0 | 15.38 | 86.1 | 0 | |
| 01/24/2024 | 10:43:37 | 88 | 1.7 | 12.33 | 86.5 | 0 | |
| 01/24/2024 | 10:45:07 | 67 | 2.3 | 11.89 | 89.6 | 0 | |
| 01/24/2024 | 10:46:37 | 75 | 2.2 | 12.45 | 93.1 | 0 | |
| 01/24/2024 | 10:47:40 | 9 | 0.7 | 12.72 | 95.6 | 0 | End Spacer |
| 01/24/2024 | 10:47:42 | 11 | 0.1 | 12.77 | 95.6 | 0 | Pumped 9bbls of 12.0ppg MPE. |
| 01/24/2024 | 10:47:47 | 11 | 0.0 | 12.78 | 95.6 | 0 | Start Displacement |
| 01/24/2024 | 10:47:49 | 12 | 0.0 | 12.78 | 95.6 | 0 | Displace with OBM. |
| 01/24/2024 | 10:48:07 | 10 | 0.0 | 12.79 | 95.6 | 0 | |
| 01/24/2024 | 10:49:37 | 430 | 4.2 | 9.79 | 99.0 | 0 | |
| 01/24/2024 | 10:51:07 | 271 | 4.2 | 9.60 | 105.3 | 0 | |
| 01/24/2024 | 10:52:37 | 362 | 4.8 | 9.55 | 112.2 | 0 | |
| 01/24/2024 | 10:54:07 | 283 | 4.9 | 9.56 | 119.5 | 0 | |
| 01/24/2024 | 10:55:37 | 289 | 5.9 | 9.55 | 127.8 | 0 | |
| 01/24/2024 | 10:57:07 | 450 | 6.4 | 9.55 | 137.2 | 0 | |
| 01/24/2024 | 10:58:37 | 434 | 6.4 | 9.55 | 146.9 | 0 | |
| 01/24/2024 | 11:00:07 | 429 | 6.4 | 9.55 | 156.5 | 0 | |
| 01/24/2024 | 11:01:37 | 321 | 5.8 | 9.55 | 165.5 | 0 | |
| 01/24/2024 | 11:03:07 | 401 | 6.4 | 9.55 | 175.0 | 0 | |
| 01/24/2024 | 11:04:37 | 430 | 6.4 | 9.55 | 184.7 | 0 | |
| 01/24/2024 | 11:06:07 | 427 | 6.4 | 9.55 | 194.3 | 0 | |
| 01/24/2024 | 11:07:37 | 11 | 0.0 | 9.55 | 202.6 | 0 | |
| 01/24/2024 | 11:09:07 | 14 | 0.1 | 9.54 | 202.6 | 0 | |
| 01/24/2024 | 11:12:07 | 455 | 4.1 | 9.54 | 215.3 | 0 | |
| 01/24/2024 | 11:12:35 | 88 | 0.0 | 9.54 | 215.8 | 0 | End Displacement |
| 01/24/2024 | 11:12:37 | 85 | 0.0 | 9.55 | 215.8 | 0 | Pumped 120bbls of OBM. |
| 01/24/2024 | 11:12:42 | 79 | 0.0 | 9.55 | 215.8 | 0 | End Job |
| 01/24/2024 | 11:12:44 | 79 | 0.0 | 9.55 | 215.8 | 0 | Turnover to rig to pull out of cement plug. |
| 01/24/2024 | 11:13:37 | 80 | 0.0 | 9.55 | 215.8 | 0 | |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/24/2024 | TALLGRASS ENERGY | EQX9-00083 |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/24/2024 | 11:16:37 | 81 | 1.9 | 9.53 | 217.3 | 0 | |

## Post Job Summary

| Average Pump Rates, bbl/min | | | | Volume of Fluid Injected, bbl | | | |
|---|---|---|---|---|---|---|---|
| Slurry | N2 | Mud | Maximum Rate | Total Slurry | Mud | Spacer | N2 |
| 3.1 | | | 6.5 | 59.0 | 0.0 | 25.0 | |

| Treating Pressure Summary, psi | | | | | Breakdown Fluid | | |
|---|---|---|---|---|---|---|---|
| Maximum | Final | Average | Bump Plug to | Breakdown | Type | Volume | Density |
| 2526 | 79 | 247 | | | | bbl | lb/gal |

| Avg. N2 Percent | Designed Slurry Volume | Displacement | Mix Water Temp | | |
|---|---|---|---|---|---|
| % | 59.0 bbl | 123.0 bbl | 60 degF | Cement Circulated to Surface? ☐ | Volume bbl |
| | | | | Washed Thru Perfs ☐ | To ft |

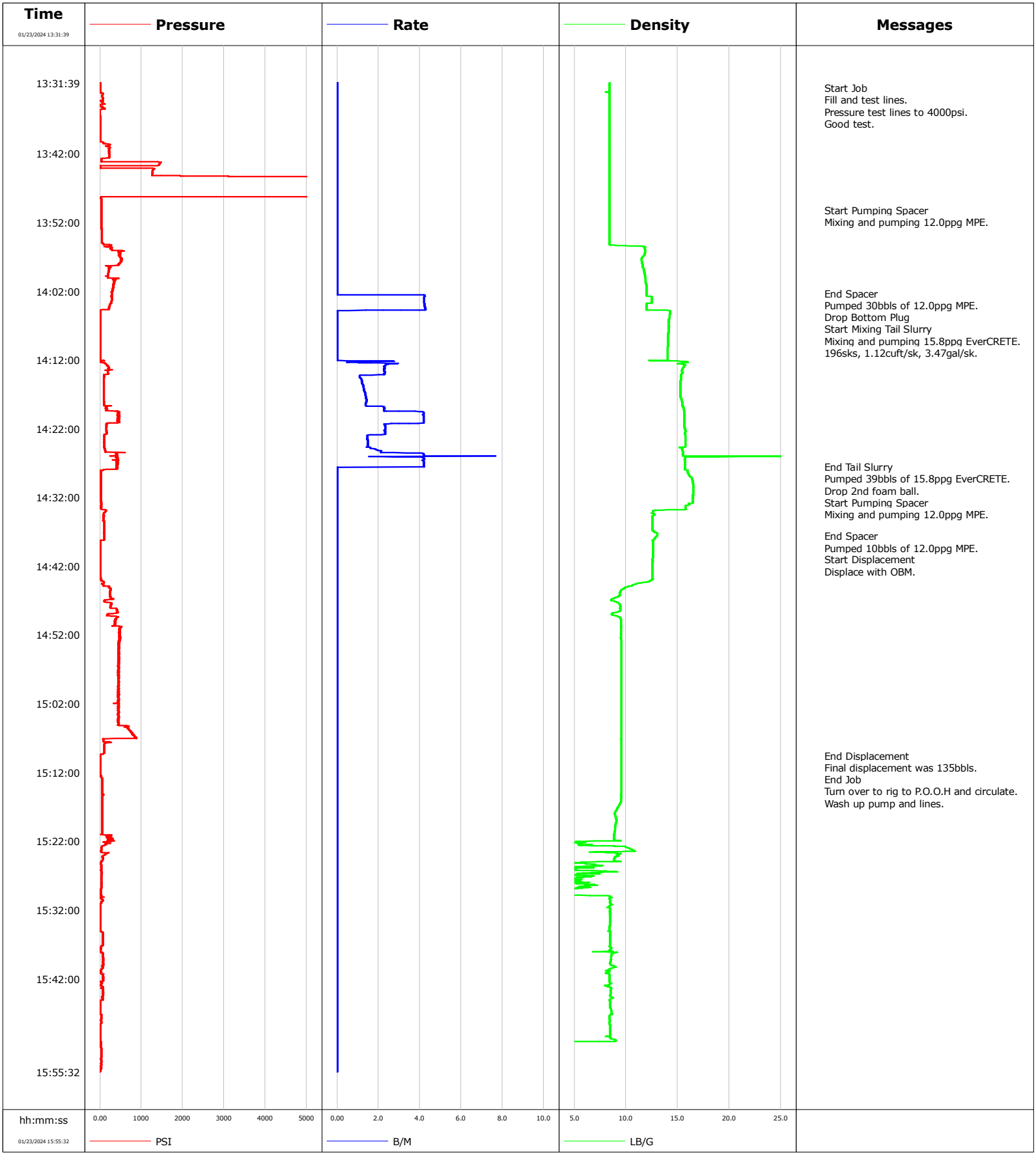
| Customer or Authorized Representative | Schlumberger Supervisor | Circulation Lost | Job Completed |
|---|---|---|---|
| | JEFFREY PATTERSON | ☐ | ☒ |
| | | - | - |

# Schlumberger

# Cementing Job Report



| | | | |
|---|---|---|---|
| **Well** | CYPRESS M-2 | **Client** | TALLGRASS ENERGY |
| **Field** | | **SIR No.** | EQX9-00083 |
| **Engineer** | JEFFREY PATTERSON | **Job Type** | PLUG |
| **Country** | United States | **Job Date** | 01-23-2024 |



Schlumberger

# Cementing Service Report

| Customer | Job Number |
|---|---|
| TALLGRASS ENERGY | EQX9-00083 |

| Well | Location (legal) | Schlumberger Location | Job Start |
|---|---|---|---|
| CYPRESS M-2 M-2 | | WINDSOR | Jan/23/2024 |

| Field | Formation Name/Type | Deviation | Bit Size | Well MD | Well TVD |
|---|---|---|---|---|---|
| | | deg | 8.8 in | 9081.0 ft | 9081.0 ft |

| County | State/Province | BHP | BHST | BHCT | Pore Press. Gradient |
|---|---|---|---|---|---|
| LARAMIE | Wyoming | psi | 263 degF | 216 degF | lb/gal |

| Well Master | API/UWI |
|---|---|
| 0067006788 | 49-021-29598-00 |

| Rig Name | Drilled For | Service Via |
|---|---|---|
| TRUE 38 | Injection (Gas) | Land |

| Offshore Zone | Well Class | Well Type |
|---|---|---|
| | New | Exploration |

| Drilling Fluid Type | Max. Density | Plastic Viscosity |
|---|---|---|
| | lb/gal | cP |

| Service Line | Job Type |
|---|---|
| Cementing | PLUG |

| Max. Allowed Tub. Press | Max. Allowed Ann. Press | WH Connection |
|---|---|---|
| psi | psi | 4 1/2" IF DP pin |

**Service Instructions**

196SKS, 1.12CUFT/SK, 3.47GAL/SK= 39BBLS OF 15.8PPG EVERCRETE.

**Casing/Liner**

| Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|
| | | | | |
| | | | | |

**Tubing/Drill Pipe**

| T/D | Depth, ft | Size, in | Weight, lb/ft | Grade | Thread |
|---|---|---|---|---|---|
| D | 8928.0 | 5.0 | 19.5 | | |
| | 0.0 | 0.0 | 0.0 | | |

**Perforations/Open Hole**

| Top, ft | Bottom, ft | shot/ft | No. of Shots | Total Interval |
|---|---|---|---|---|
| ft | ft | | | ft |
| ft | ft | | | Diameter |
| ft | ft | | | in |

| Treat Down | Displacement | Packer Type | Packer Depth |
|---|---|---|---|
| Drill Pipe | 135.0 bbl | | ft |

| Tubing Vol. | Casing Vol. | Annular Vol. | Openhole Vol. |
|---|---|---|---|
| 139.1 bbl | bbl | bbl | bbl |

| Casing/Tubing Secured | 1 Hole Vol. Circulated prior to Cement |
|---|---|
| X | X |

| Lift Pressure | | |
|---|---|---|
| psi | | |

| Pipe Rotated | Pipe Reciprocated |
|---|---|
| ☐ | ☐ |

| No. Centralizers | Top Plugs | Bottom Plugs |
|---|---|---|
| | | |

| Cement Head Type |
|---|
| |

| Job Scheduled For | Arrived on Location | Leave Location |
|---|---|---|
| Jan/23/2024 08:00 | Jan/23/2024 08:00 | Jan/23/2024 16:00 |

| Casing Tools | | Squeeze Job | |
|---|---|---|---|
| Shoe Type | | Squeeze Type | |
| Shoe Depth | ft | Tool Type | |
| Stage Tool Type | | Tool Depth | ft |
| Stage Tool Depth | ft | Tail Pipe Size | in |
| Collar Type | | Tail Pipe Depth | ft |
| Collar Depth | ft | Sqz. Total Vol. | bbl |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/23/2024 | 13:31:39 | 1 | 0.0 | 8.40 | 2.2 | 0 | Started Acquisition |
| 01/23/2024 | 13:32:25 | 0 | 0.0 | 8.40 | 2.2 | 0 | Start Job |
| 01/23/2024 | 13:32:27 | 1 | 0.0 | 8.40 | 2.2 | 0 | Fill and test lines. |
| 01/23/2024 | 13:32:28 | 1 | 0.0 | 8.40 | 2.2 | 0 | Good test. |
| 01/23/2024 | 13:33:09 | 56 | 0.9 | 8.39 | 2.2 | 0 | |
| 01/23/2024 | 13:34:39 | 63 | 3.2 | 8.39 | 3.3 | 0 | |
| 01/23/2024 | 13:36:09 | -2 | 0.4 | 8.40 | 6.3 | 0 | |
| 01/23/2024 | 13:37:39 | 2 | 0.0 | 8.41 | 6.4 | 0 | |
| 01/23/2024 | 13:39:09 | 3 | 0.0 | 8.41 | 6.4 | 0 | |
| 01/23/2024 | 13:40:39 | 244 | 1.9 | 8.40 | 0.6 | 0 | |
| 01/23/2024 | 13:42:09 | 221 | 2.3 | 8.39 | 3.8 | 0 | |
| 01/23/2024 | 13:43:39 | 1425 | 0.0 | 8.39 | 5.0 | 0 | |
| 01/23/2024 | 13:45:09 | 1369 | 0.0 | 8.39 | 5.1 | 0 | |
| 01/23/2024 | 13:46:39 | 6908 | 0.0 | 8.39 | 5.1 | 0 | |
| 01/23/2024 | 13:48:09 | 6908 | 0.0 | 8.39 | 5.1 | 0 | |
| 01/23/2024 | 13:49:39 | 28 | 0.0 | 8.40 | 5.1 | 0 | |
| 01/23/2024 | 13:50:11 | 29 | 0.0 | 8.40 | 5.1 | 0 | Start Pumping Spacer |
| 01/23/2024 | 13:50:12 | 29 | 0.0 | 8.39 | 5.1 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/23/2024 | 13:51:09 | 31 | 0.0 | 8.39 | 5.1 | 0 | |
| 01/23/2024 | 13:52:39 | 35 | 0.0 | 8.39 | 5.1 | 0 | |
| 01/23/2024 | 13:54:09 | 39 | 0.0 | 8.39 | 5.1 | 0 | |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/23/2024 | TALLGRASS ENERGY | EQX9-00083 |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/23/2024 | 13:57:09 | 502 | 4.2 | 11.53 | 11.3 | 0 | |
| 01/23/2024 | 13:58:39 | 211 | 2.3 | 11.70 | 16.9 | 0 | |
| 01/23/2024 | 14:00:09 | 429 | 4.0 | 11.86 | 20.4 | 0 | |
| 01/23/2024 | 14:01:39 | 313 | 4.2 | 11.97 | 26.8 | 0 | |
| 01/23/2024 | 14:02:19 | 300 | 4.2 | 11.97 | 29.6 | 0 | End Spacer |
| 01/23/2024 | 14:02:21 | 282 | 4.2 | 11.97 | 29.7 | 0 | Pumped 30bbls of 12.0ppg MPE. |
| 01/23/2024 | 14:02:24 | 291 | 4.2 | 11.97 | 29.9 | 0 | Drop Bottom Plug |
| 01/23/2024 | 14:02:30 | 294 | 4.2 | 11.97 | 30.3 | 0 | Start Mixing Tail Slurry |
| 01/23/2024 | 14:02:31 | 291 | 4.2 | 11.97 | 30.4 | 0 | Mixing and pumping 15.8ppg EverCRETE. |
| 01/23/2024 | 14:03:09 | 279 | 4.2 | 12.52 | 33.1 | 0 | |
| 01/23/2024 | 14:04:39 | 205 | 4.3 | 11.97 | 39.4 | 0 | |
| 01/23/2024 | 14:06:09 | 3 | 0.0 | 14.14 | 39.8 | 0 | |
| 01/23/2024 | 14:07:39 | 3 | 0.0 | 14.12 | 39.8 | 0 | |
| 01/23/2024 | 14:09:09 | 5 | 0.0 | 14.07 | 39.8 | 0 | |
| 01/23/2024 | 14:10:39 | 4 | 0.0 | 14.04 | 39.8 | 0 | |
| 01/23/2024 | 14:12:09 | 36 | 2.8 | 15.00 | 39.9 | 0 | |
| 01/23/2024 | 14:13:39 | 193 | 2.3 | 15.42 | 43.2 | 0 | |
| 01/23/2024 | 14:15:09 | 91 | 1.2 | 15.27 | 45.5 | 0 | |
| 01/23/2024 | 14:16:39 | 92 | 1.3 | 15.26 | 47.4 | 0 | |
| 01/23/2024 | 14:18:09 | 96 | 1.4 | 15.43 | 49.4 | 0 | |
| 01/23/2024 | 14:19:39 | 435 | 4.2 | 15.63 | 52.8 | 0 | |
| 01/23/2024 | 14:21:09 | 351 | 4.2 | 15.63 | 59.0 | 0 | |
| 01/23/2024 | 14:22:39 | 154 | 2.3 | 15.69 | 62.6 | 0 | |
| 01/23/2024 | 14:24:09 | 96 | 1.5 | 15.74 | 65.0 | 0 | |
| 01/23/2024 | 14:25:39 | 409 | 4.2 | 15.48 | 68.0 | 0 | |
| 01/23/2024 | 14:27:34 | 434 | 4.2 | 15.69 | 75.9 | 0 | End Tail Slurry |
| 01/23/2024 | 14:27:36 | 409 | 4.2 | 15.69 | 76.0 | 0 | Pumped 39bbls of 15.8ppg EverCRETE. |
| 01/23/2024 | 14:27:42 | 422 | 4.2 | 15.68 | 76.4 | 0 | Drop 2nd foam ball. |
| 01/23/2024 | 14:27:48 | 386 | 4.2 | 15.69 | 76.9 | 0 | Start Pumping Spacer |
| 01/23/2024 | 14:27:49 | 405 | 4.2 | 15.69 | 76.9 | 0 | Mixing and pumping 12.0ppg MPE. |
| 01/23/2024 | 14:28:39 | 21 | 0.0 | 16.07 | 77.7 | 0 | |
| 01/23/2024 | 14:30:09 | 21 | 0.0 | 16.50 | 77.7 | 0 | |
| 01/23/2024 | 14:31:39 | 23 | 0.0 | 16.48 | 77.7 | 0 | |
| 01/23/2024 | 14:33:09 | 24 | 0.0 | 15.83 | 77.7 | 0 | |
| 01/23/2024 | 14:34:39 | 77 | 2.2 | 12.56 | 79.7 | 0 | |
| 01/23/2024 | 14:36:09 | 100 | 2.6 | 12.54 | 83.3 | 0 | |
| 01/23/2024 | 14:37:36 | 100 | 2.4 | 12.99 | 87.1 | 0 | End Spacer |
| 01/23/2024 | 14:37:37 | 103 | 2.4 | 12.98 | 87.1 | 0 | Pumped 10bbls of 12.0ppg MPE. |
| 01/23/2024 | 14:37:39 | 102 | 2.4 | 12.94 | 87.2 | 0 | |
| 01/23/2024 | 14:37:48 | 100 | 2.3 | 12.84 | 87.5 | 0 | Start Displacement |
| 01/23/2024 | 14:37:50 | 101 | 2.3 | 12.82 | 87.6 | 0 | Displace with OBM. |
| 01/23/2024 | 14:39:09 | 7 | 0.0 | 12.59 | 88.7 | 0 | |
| 01/23/2024 | 14:40:39 | 9 | 0.0 | 12.57 | 88.7 | 0 | |
| 01/23/2024 | 14:42:09 | 11 | 0.0 | 12.57 | 88.7 | 0 | |
| 01/23/2024 | 14:43:39 | 12 | 0.0 | 12.55 | 88.7 | 0 | |
| 01/23/2024 | 14:45:09 | 240 | 4.2 | 9.84 | 91.2 | 0 | |
| 01/23/2024 | 14:46:39 | 288 | 4.2 | 8.88 | 97.5 | 0 | |
| 01/23/2024 | 14:48:09 | 393 | 5.1 | 9.43 | 103.8 | 0 | |
| 01/23/2024 | 14:49:39 | 386 | 5.4 | 9.47 | 112.0 | 0 | |
| 01/23/2024 | 14:51:09 | 461 | 6.4 | 9.50 | 120.5 | 0 | |
| 01/23/2024 | 14:52:39 | 477 | 6.4 | 9.53 | 130.1 | 0 | |
| 01/23/2024 | 14:54:09 | 445 | 6.4 | 9.54 | 139.8 | 0 | |
| 01/23/2024 | 14:55:39 | 456 | 6.4 | 9.53 | 149.4 | 0 | |
| 01/23/2024 | 14:57:09 | 446 | 6.4 | 9.54 | 159.1 | 0 | |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/23/2024 | TALLGRASS ENERGY | EQX9-00083 |

| Date | Time 24-hr clock | Treating Pressure PSI | Flow Rate B/M | Density LB/G | Volume BBL | Backside NULL | Message |
|---|---|---|---|---|---|---|---|
| 01/23/2024 | 15:00:09 | 471 | 6.4 | 9.54 | 178.4 | 0 | |
| 01/23/2024 | 15:01:39 | 452 | 6.4 | 9.54 | 188.0 | 0 | |
| 01/23/2024 | 15:03:09 | 458 | 6.4 | 9.53 | 197.6 | 0 | |
| 01/23/2024 | 15:04:39 | 428 | 6.4 | 9.54 | 207.3 | 0 | |
| 01/23/2024 | 15:06:09 | 776 | 6.4 | 9.54 | 216.9 | 0 | |
| 01/23/2024 | 15:07:39 | 190 | 1.1 | 9.53 | 223.4 | 0 | |
| 01/23/2024 | 15:09:09 | 105 | 0.0 | 9.53 | 223.4 | 0 | |
| 01/23/2024 | 15:09:31 | 5 | 0.0 | 9.53 | 223.4 | 0 | End Displacement |
| 01/23/2024 | 15:09:33 | 5 | 0.0 | 9.53 | 223.4 | 0 | Final displacement was 135bbls. |
| 01/23/2024 | 15:09:39 | 6 | 0.0 | 9.53 | 223.4 | 0 | End Job |
| 01/23/2024 | 15:09:42 | 6 | 0.0 | 9.53 | 223.4 | 0 | Turn over to rig to P.O.O.H and circulate. |
| 01/23/2024 | 15:10:39 | 6 | 0.0 | 9.53 | 223.4 | 0 | |
| 01/23/2024 | 15:12:09 | 5 | 0.0 | 9.54 | 223.4 | 0 | |
| 01/23/2024 | 15:13:39 | 55 | 1.5 | 9.56 | 223.4 | 0 | |
| 01/23/2024 | 15:15:09 | 79 | 1.4 | 9.53 | 223.4 | 0 | |
| 01/23/2024 | 15:16:39 | 56 | 1.5 | 9.37 | 223.4 | 0 | |
| 01/23/2024 | 15:18:09 | 56 | 0.7 | 8.92 | 223.4 | 0 | |
| 01/23/2024 | 15:19:39 | 56 | 0.4 | 8.97 | 223.4 | 0 | |
| 01/23/2024 | 15:21:09 | 162 | 1.9 | 8.87 | 223.4 | 0 | |
| 01/23/2024 | 15:22:39 | 61 | 0.8 | 7.85 | 223.4 | 0 | |
| 01/23/2024 | 15:24:09 | 57 | 2.6 | 9.22 | 223.4 | 0 | |
| 01/23/2024 | 15:25:39 | 31 | 1.9 | 5.53 | 223.4 | 0 | |
| 01/23/2024 | 15:27:09 | 35 | 2.0 | 6.71 | 223.4 | 0 | |
| 01/23/2024 | 15:28:39 | 36 | 2.7 | 6.48 | 223.4 | 0 | |
| 01/23/2024 | 15:30:09 | 40 | 1.7 | 8.55 | 223.4 | 0 | |
| 01/23/2024 | 15:31:39 | 8 | 0.2 | 8.32 | 223.4 | 0 | |
| 01/23/2024 | 15:33:09 | 8 | 0.0 | 8.43 | 223.4 | 0 | |
| 01/23/2024 | 15:34:39 | 9 | 0.0 | 8.43 | 223.4 | 0 | |
| 01/23/2024 | 15:36:09 | 68 | 2.3 | 8.43 | 223.4 | 0 | |
| 01/23/2024 | 15:37:39 | 13 | 1.3 | 8.51 | 223.4 | 0 | |
| 01/23/2024 | 15:39:09 | 71 | 2.4 | 8.53 | 223.4 | 0 | |
| 01/23/2024 | 15:40:39 | 28 | 1.4 | 8.31 | 223.4 | 0 | |
| 01/23/2024 | 15:42:09 | 72 | 2.4 | 8.39 | 223.4 | 0 | |
| 01/23/2024 | 15:43:39 | 70 | 2.4 | 8.51 | 223.4 | 0 | |
| 01/23/2024 | 15:45:09 | 11 | 1.8 | 8.41 | 223.4 | 0 | |
| 01/23/2024 | 15:46:39 | 4 | 0.1 | 8.58 | 223.4 | 0 | |
| 01/23/2024 | 15:48:09 | 24 | 0.0 | 8.43 | 223.4 | 0 | |
| 01/23/2024 | 15:49:39 | 7 | 0.0 | 8.44 | 223.4 | 0 | |
| 01/23/2024 | 15:51:09 | 18 | 1.1 | 4.94 | 223.4 | 0 | |
| 01/23/2024 | 15:52:39 | 33 | 1.1 | 0.13 | 223.4 | 0 | |

| Well | Field | Job Start | Customer | Job Number |
|---|---|---|---|---|
| CYPRESS M-2 M-2 | | Jan/23/2024 | TALLGRASS ENERGY | EQX9-00083 |

# Post Job Summary

| Average Pump Rates, bbl/min | | | | Volume of Fluid Injected, bbl | | | |
|---|---|---|---|---|---|---|---|
| Slurry | N2 | Mud | Maximum Rate | Total Slurry | Mud | Spacer | N2 |
| 2.5 | | | 25.0 | 39.0 | 0.0 | 40.0 | |

| Treating Pressure Summary, psi | | | | | Breakdown Fluid | | |
|---|---|---|---|---|---|---|---|
| Maximum | Final | Average | Bump Plug to | Breakdown | Type | Volume | Density |
| 6930 | 7 | 297 | | | | bbl | lb/gal |

| Avg. N2 Percent | Designed Slurry Volume | Displacement | Mix Water Temp | Cement Circulated to Surface? | Volume |
|---|---|---|---|---|---|
| % | 39.0 bbl | 135.0 bbl | 60 degF | ☐ | bbl |
| | | | | Washed Thru Perfs ☐ | To ft |

| Customer or Authorized Representative | Schlumberger Supervisor | Circulation Lost | Job Completed |
|---|---|---|---|
| | JEFFREY PATTERSON | - | - ☒ |

# Plug Cementing Program

# Cypress M2
# Surface Cap

version 5

1/22/2024

**Rig : True Drilling 38**


Prepared for :
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## Operational Risk Statement

Cement plugs are complex in design and execution, and should not underestimated. Cement plugs should never be considered as a 'routine' job. To successfully set cement plugs the same methodology used to design and execute primary cement jobs is required (e.g. correct slurry design, mud-removal and placement design based on accurate well data). Cement plugs are remedial cementing treatments. The first logical step is to determine the actual problem to solve, i.e. what is the purpose of setting a cement plug. The second step is to understand the criteria of evaluation (tag / no tag, positive pressure test, negative test, etc.). Both of these steps allow for the proper selection of the slurry specification and job placement technique. This can include more laboratory tests as well as additional equipment requirements.

Well Cementing (Nelson, 2006) discusses several key factors for successful plug cementing operation

1. Displacement and under-displacement volumes play a critical role for the success of the job and should be followed as per this program.
2. Fluid contamination/mixing during plug setting can reduce job success; use of a stable base, mechanical separators, and appropriate wait-on-cement-time are strongly recommended.
3. In case of a Kick-off Plug, proper knowledge of the BHA and correct drilling techniques are required

In case of any deviation from the approved job procedure, a Management of Change (MoC) is required. By raising a MoC to the appropriate level within the operator organization as well as Schlumberger Well Services, all the operational risks can be identified and addressed prior to execution of the cement plug.

| Tubulars and Casing Hardware | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **MD** ft | **OD** in | **Weight** lb/ft | **Grade** | **ID** in | **Thread** | **Collapse** psi | **Burst** psi | **Joint** ft |
| **Prev Casing** | 1551.5.00 | 9 5/8 | 40.00 | J-55 | 8.835 | | 2570 | 3950 | 1.00 |
| **Workstring** | 200.00 | 5 | 19.50 | E75 | 4.276 | | 10000 | 9500 | 40.00 |
| **Dart/Ball Launch Manifold** | N/A | | | | | | | | |

| Open Hole | |
|---|---|
| Total OH Volume : | 560.6374 bbl |
| Minimum Diameter : | 8.750 in |
| Maximum Diameter : | 8.750 in |

| | |
|---|---|
| Mean Diameter : | 8.750 in |
| Mean Eq. Diameter : | 8.750 in |

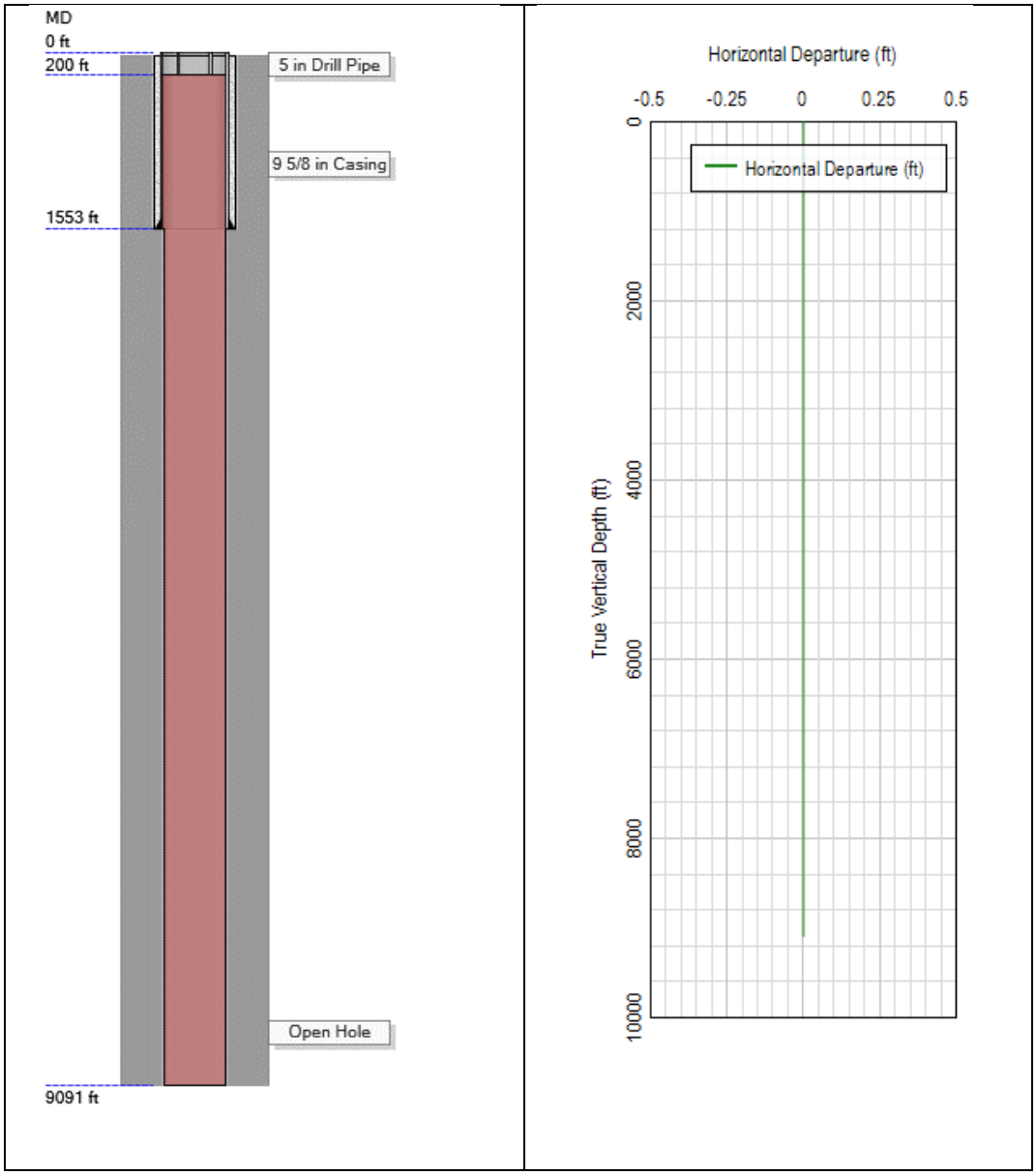
| Temperature Simulation | |
|---|---|
| BHST | 64.60 degF |
| Simulated BHCT | 79.97 degF |

| Objective & Placement Conditions | |
|---|---|
| **Top of plug:** | **17.21 ft** |
| Plug Length : | 182.79 ft |
| **Bottom of plug:** | **200.00 ft** |
| **Support :** | **Previous plug + viscous pill** |

| | |
|---|---|
| Mechanical Separator : | Foam balls |
| Pipe Rotation / Reciprocation : | N/A |



SLB-Private






SLB-Private

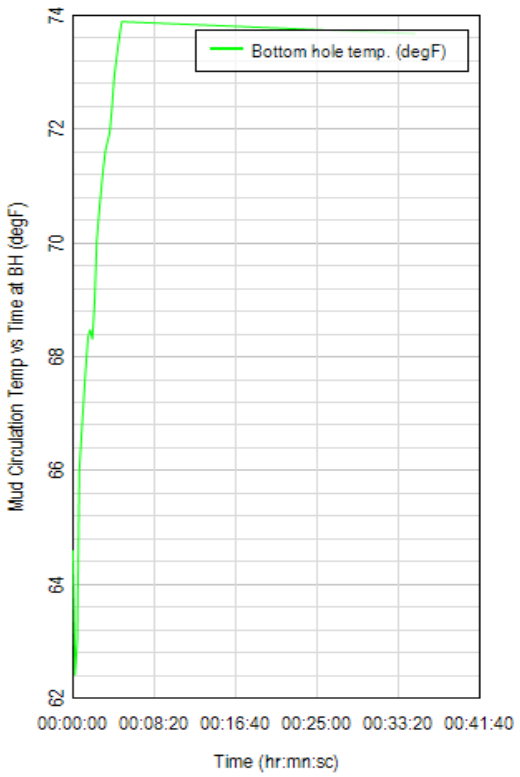
Schlumberger

1. Confirm well data and calculations with Wellsite Rep., minimum but not limited to: pipe tally and capacities (including the stinger if applicable), pumping schedule, drilling fluid properties, anticipated pressures during the job, WOC and contingencies.

   Confirm the placement of a support for the plug. In the case of a pill (mud or reactive), verify placement depth, volume and rheological properties.

2. RIH to the bottom of the cement plug at **200.00 ft**
3. Rig up as per WS STD 5 and pressure test the line 1000psi above the maximum expected pressure
4. Confirm the well is circulated as per the following schedule

| Mud Circulation | | | |
|---|---|---|---|
| **Fluid** | **Pump Rate** bbl/min | **Duration** hr:mn:sc | **Volume** bbl |
| OBM | 8.0 | 00:05:00 | 40.0000 |
| Pause | | 00:30:00 | |




Initiate a MOC if there is a significant deviation (>20%) of the pump pressure from the theoretical value, which may indicate an obstruction or hole instability.



SLB-Private

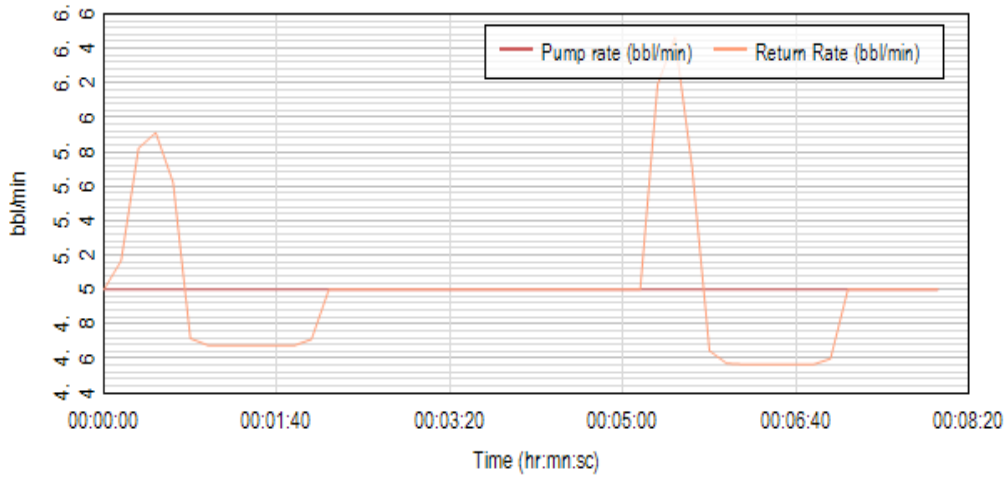
5. Prepare the spacer and the mix fluid for the cement slurry.

⚠ Account for dead volumes and peer-check additives calculations

6. Execute the following pumping schedule

| Pumping Schedule | | | | | | |
|---|---|---|---|---|---|---|
| **Fluid Name** | **Stage Volume** bbl | **Pump Rate** bbl/min | **Stage Time** hr:mn:sc | **Cum. Time** hr:mn:sc | **Comment** | **Inj. Temp.** degF |
| MUDPUSH Express | 25.0000 | 5.0 | 00:05:00 | 00:05:00 | | 80.00 |
| G P1 | 15.1654 | 5.0 | 00:03:02 | 00:08:02 | | 80.00 |

| | |
|---|---|
| **Note:** Total displacement volume accounts for an under-displacement of (bbl) | .0001 |




7. Disconnect the SLB line

8. Pull out of the hole to 0.00 ft

9. No direct circulation needed.

10. Rig down and wash equipment



SLB-Private

Schlumberger




# Cypress M2
# Surface Casing Plug
version 5 plug 2
1/22/2024

Rig : True Drilling 38

Prepared for:
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720 369 8051
jvaladez2@slb.com

# Job Objectives and Design Considerations

## Job Objectives

Mud company to spot 500' viscous pill below 1651.5' prior cement operations to support plug.
Cement balanced plug to abandon well with surface casing at 1551.5' from 1651.5-1401.5' (150' above shoe and 100' below, 250' plug length) in 8 3/4" OH (5% excess over caliper), no plan of tagging (expected TOC ~1418'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl. POOH 300' above theoretical TOC (1101.5) @ 40'/min rotating pipe slow and circulate to clean out excess.

## Acceptance Criteria

Pump plug as per design

### Operational Risk Statement

Cement plugs operations are complex to design and execute and this complexity should not be underestimated. Cement plugs operations should never be considered as a "routine" job. To successfully set cement plugs the same methodology used to design and execute primary cement jobs is required, which includes but is not limited to correct slurry design, mud-removal and placement design based on accurate well data. Cement plugs are remedial cementing treatments. The first design step is the determination of the actual problem to solve, i.e. define the purpose of setting a cement plug. The second step consists in defining the evaluation criteria: tag / no tag, positive pressure test, negative test, etc. Both steps allow for the proper specification of slurry properties and the determination of the adequate plug placement technique. This can result in additional laboratory tests as well as additional equipment requirements.

Nelson in Well Cementing (2006) discusses several factors that are key to successful plug cementing operations.
Displacement and under-displacement volumes play a critical role for the success of the job. The volumes specified in this program should be followed.
Fluid contamination/mixing during plug setting can jeopardize job success. To mitigate this risk, using a stable base for the plug, mechanical separators, and appropriate wait-on-cement-time is strongly recommended.
In case of a Kick-off Plug, proper knowledge of the BHA and application of correct drilling techniques are required to kick-off.

In case of any deviation from the approved job procedure, a Management of Change (MoC) is required. By raising a MoC to the appropriate level within the operator organization as well as within SLB, all the operational risks can be identified and addressed prior to execution of the cement plug.

# Plug Operation Summary

Overview of the cementing operation (temperatures, fluid types, rates and general notes)
**All depths (except water depth) take the rig floor as reference**

## Well & Rig Information

| | |
|---|---|
| Rig Type: | Land |

Objective: Mud company to spot 500' viscous pill below 1651.5' prior cement operations to support plug.
Cement balanced plug to abandon well with surface casing at 1551.5' from 1651.5-1401.5' (150' above shoe and 100' below, 250' plug length) in 8 3/4" OH (5% excess over caliper), no plan of tagging (expected TOC ~1418'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (1101.5) @ 40'/min rotating pipe slow and circulate to clean out excess.

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |
| Well Deviation: | 0.0 deg |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Placement & Post-Placement Conditions

| | |
|---|---|
| **Top:** | **1401.5 ft** |
| Length: | 250.0 ft |
| **Bottom:** | **1651.5 ft** |
| **Support:** | **VISCOUS PILL** |

| | |
|---|---|
| Mechanical Separator: | AHEAD AND BEHIND |
| Pipe Rotation / Reciprocation: | ROTATION |

| | |
|---|---|
| POOH Depth: | 1101.5 ft |
| POOH Speed: | 30-40FT/MIN |
| Circ. Rate: | 8.0 bbl/min |
| Circ. Direction: | Direct |

| | |
|---|---|
| String type and configuration: | OPEN ENDED |

## Design Considerations

| G P2 | |
|---|---|
| Cement Type: | Slurry |
| Slurry Dens.: | 15.80 lb/gal |

| MUDPUSH Express | |
|---|---|
| Spacer Type: | Spacer |
| Spacer Dens.: | 12.00 lb/gal |

| OBM | |
|---|---|
| Mud Type: | Oil Based Mud |
| Mud Dens.: | 9.40 lb/gal |

| | | | |
|---|---|---|---|
| **Volume Balance Model:** | Optimize Slurry & Spacer | Underdispl.: | 0.0 bbl |

## Pumping Schedule

| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Comment | Inj. Temp. degF |
|---|---|---|---|---|---|
| Pause | | | 00:00 | Circ to cool down well and cond mud 25min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.6 | 5.0 | 00:04 | | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| G P2 | 20.6 | 5.0 | 00:04 | MinTT 2:51 | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| MUDPUSH Express | 6.4 | 5.0 | 00:01 | | 80.0 |
| OBM | 18.1 | 5.0 | 00:04 | | 80.0 |
| Pause | | | 00:10 | Break cmt. lines | |



| | | | | | |
|---|---|---|---|---|---|
| Pause | | | 00:14 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:08 | Rig circ. pipe clean excess 60bbl @ 8bpm | |
| Pause | | | 00:00 | | |
| Shut-in | | | 00:00 | | |

| Temperature Simulation | | | | |
|---|---|---|---|---|
| Pre-job Circ. Rate: | 8 bbl/min | | BHST: | 89.8 degF |
| Pre-job Circ. Time: | 25 MIN | | Simulated BHCT: | 79.9 degF |

# Well Data Summary

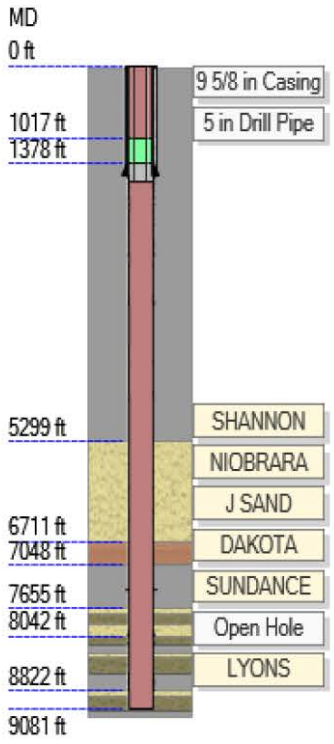
The cementing program incorporates the following data:
**All depths (except water depth) take the rig floor as reference**

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Tubulars and Casing Hardware

| | MD ft | OD in | Weight lb/ft | Grade | ID in | Thread | Collapse psi | Burst psi | Joint ft |
|---|---|---|---|---|---|---|---|---|---|
| Prev Casing | 1551.5 | 9 5/8 | 40.0 | J-55 | 8.835 | | 2570 | 3950 | 1.0 |
| Workstring | 1651.5 | 5 | 19.5 | E75 | 4.276 | | 10000 | 9500 | 40.0 |



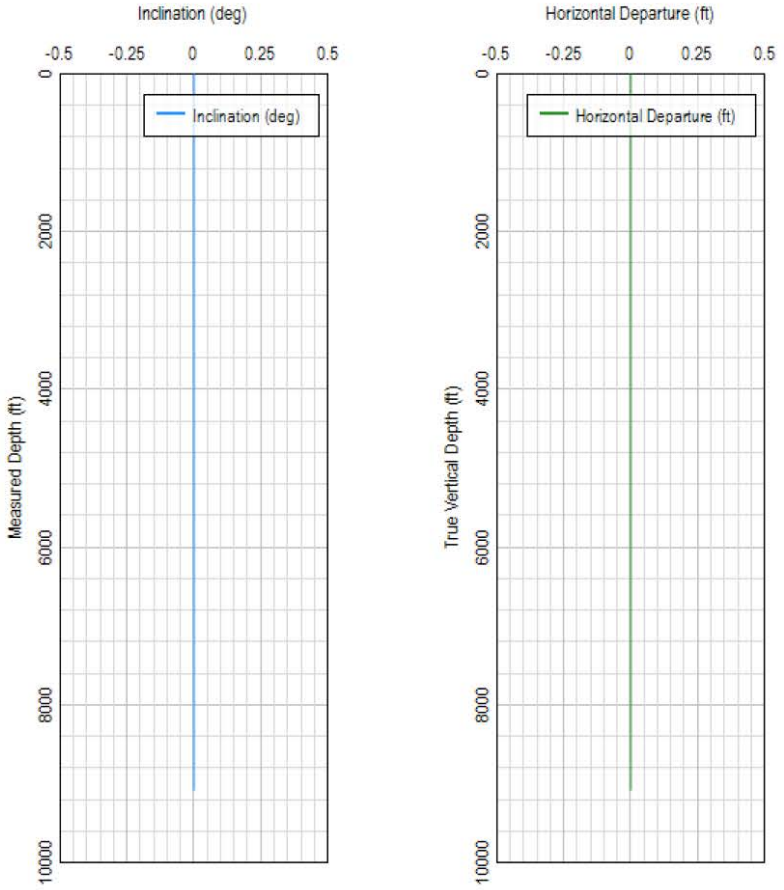

## Open Hole

| | |
|---|---|
| Total OH Volume: | 588.0 bbl |
| Minimum Diameter: | 8.473 in |
| Maximum Diameter: | 12.776 in |

| | |
|---|---|
| Mean Diameter: | 8.750 in |
| Mean Ann. Excess: | 0.000 % |
| Mean Eq. Diameter: | 8.966 in |

Note : OH caliper was uploaded.

## Directional Survey



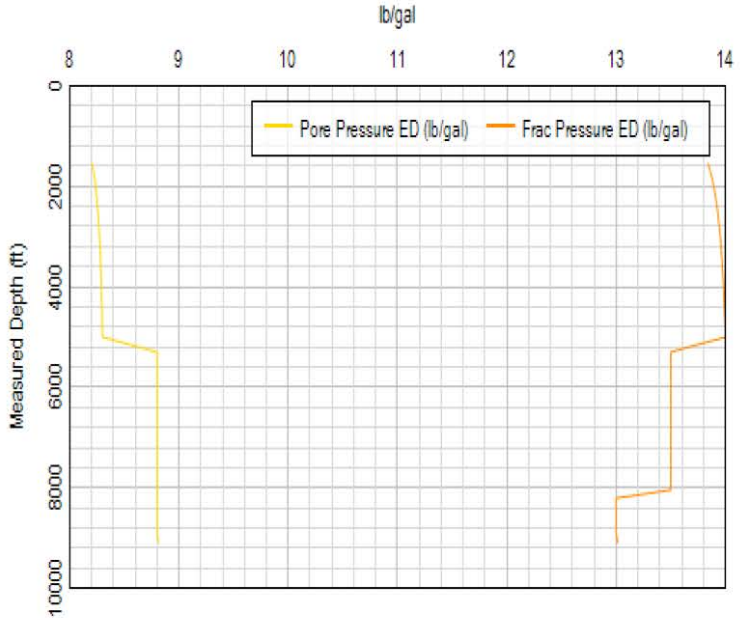

**Note:** Hole assumed vertical

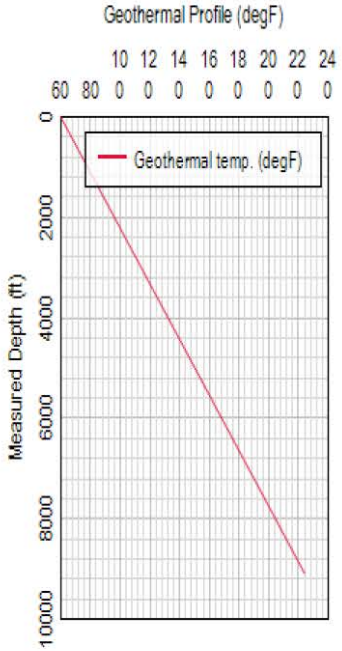
## Formation

| Top MD ft | Bottom MD ft | Bottom TVD ft | Frac Top ED lb/gal | Frac Bottom ED lb/gal | Pore Top ED lb/gal | Pore Bottom ED lb/gal | Lithology | Res. Fluid | Name |
|---|---|---|---|---|---|---|---|---|---|
| 25.5 | 5000.0 | 5000.0 | 0.00 | 14.00 | 0.00 | 8.30 | | | |
| 5000.0 | 5299.0 | 5299.0 | 14.00 | 13.50 | 8.30 | 8.80 | | | |
| 5299.0 | 6711.0 | 6711.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | SHANNON |
| 6711.0 | 7048.0 | 7048.0 | 13.50 | 13.50 | 8.80 | 8.80 | Shale | | NIOBRARA |
| 7048.0 | 7250.0 | 7250.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7250.0 | 7655.0 | 7655.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7655.0 | 7734.0 | 7734.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | J SAND |
| 7734.0 | 7894.0 | 7894.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7894.0 | 8042.0 | 8042.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | DAKOTA |
| 8042.0 | 8200.0 | 8200.0 | 13.50 | 13.00 | 8.80 | 8.80 | | | |
| 8200.0 | 8274.0 | 8274.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8274.0 | 8336.0 | 8336.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | SUNDANCE |
| 8336.0 | 8500.0 | 8500.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8500.0 | 8600.0 | 8600.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8600.0 | 8682.0 | 8682.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8682.0 | 8822.0 | 8822.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8822.0 | 8891.0 | 8891.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | LYONS |
| 8891.0 | 9081.0 | 9081.0 | 13.00 | 13.01 | 8.80 | 8.81 | | | |

| Temperature | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Top MD ft | Bottom MD ft | Bottom TVD ft | Temp. degF | Temp. Gradient degF/100ft | Temp. Rel. Gradient degF/100ft | |
| Surface | 0.0 | 0.0 | 0.0 | 60.0 | 0.00 | | |
| BHST | 0.0 | 1651.5 | 1651.5 | 89.8 | 1.81 | 1.81 | |
| Rock | 1651.5 | 9081.0 | 9081.0 | 224.0 | 1.81 | 1.81 | |

**Source of temperature data:** 224degF at BH from 3 different SLB WL Logs, confirmed with client

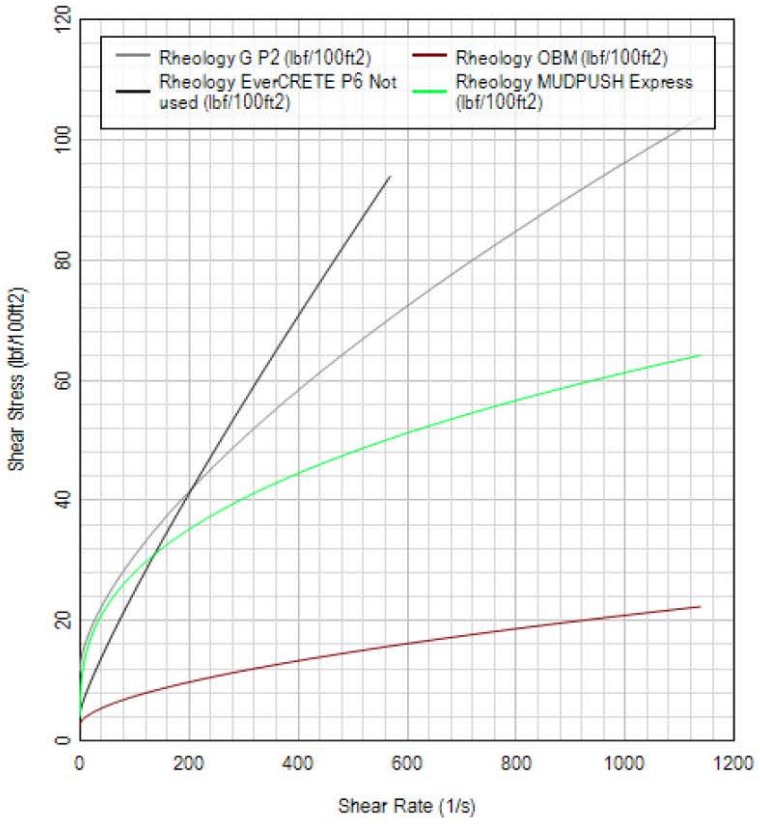


# Fluids Summary

| Fluids | | | | | | |
|---|---|---|---|---|---|---|
| Type | Name | Density lb/gal | Conditions | K lbf.s^n/ft2 | n | Ty lbf/100ft2 |
| Drilling Fluid | OBM | 9.40 | Downhole 190.0 degF | 3.03E-3 | 0.589 | 2.59 |
| Spacer | MUDPUSH Express | 12.00 | Downhole 190.0 degF WND 2023-153 | 3.94E-2 | 0.381 | 4.10 |
| Slurry | G P2 | 15.80 | Downhole 83.0 degF CWY 2020-2448 | 8.85E-3 | 0.656 | 11.54 |

* Rheology and density of compressible fluids are displayed at standard conditions, ie. P = 1 atm and T = 20 degC (65 degF)




| Fluid Density and Rheology Tolerance |
|---|
| **Mud** – properties to be verified prior to job with mud engineer, contact engineer onshore if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg rheology difference from planned : +/- 10% |
| **Spacer** – properties to be verified prior to job, see contingency plans if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg |
| **Slurry** – cement slurry should be mixed within the range described below, see contingency plans if there is mismatch between designed density and slurry volume<br>density difference from planned : +/- 0.2 ppg |

# Mud Circulation

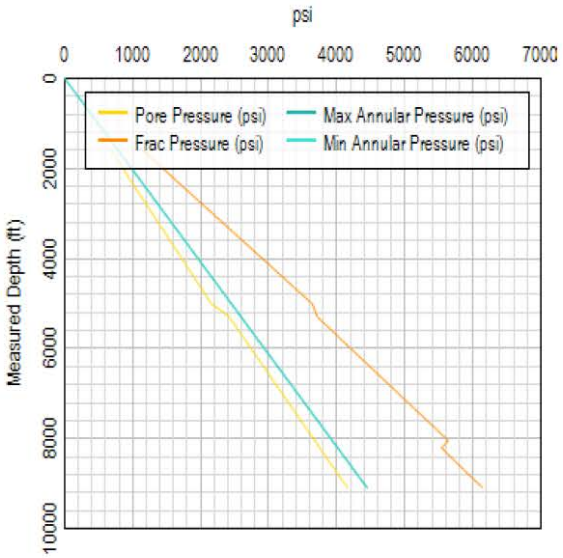
| | |
|---|---|
| Fluid | OBM |
| Number of Circulations | 1.723 |
| Total Volume at Ambient Temperature | 200.0 bbl |
| Ambient Temperature | 80.0 degF |
| Correction Slope | 0.700 |

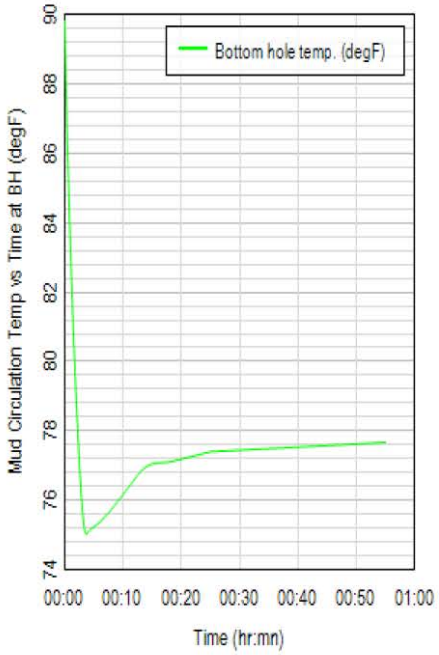
**Pumping Stages**

| Fluid | Pump Rate bbl/min | Duration hr:mn | Volume bbl |
|---|---|---|---|
| OBM | 8.0 | 00:25 | 200.0 |
| Pause | | 00:30 | |

**Well Security**

| Status | Description | Min Differential Pressure psi | At Depth ft | At Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 346 | 1551.5 | 00:25 |
| Success | Production/Influx | 96 | 1551.5 | 00:55 |
| Success | Burst | 9449 | 0.0 | 00:00 |
| Success | Collapse | 9883 | 1651.5 | 00:55 |



# Fluid Placement

## Volume Balance Objectives

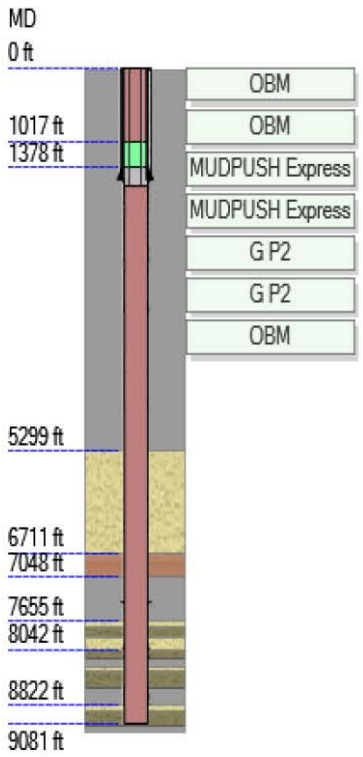
Volume Balance Model: **Optimize Slurry & Spacer**

| | | | | | |
|---|---|---|---|---|---|
| Original Fluid: | OBM | Rat Hole Fluid: | OBM | Displ. Fluid: | OBM |
| Top Spacer: | MUDPUSH Express | set Total Volume to: | 25.0 bbl | | |
| Top Slurry: | G P2 | set Top MD to: | 1401.5 ft | | |

Annulus is **not** filled during POOH.

## Volume Balance Results

| | | | | | |
|---|---|---|---|---|---|
| String Volume: | 29.3 bbl | Underdispl.: | 0.0 bbl | Displ. Volume: | 18.1 bbl |
| TOC after POOH: | 1401.5 ft | Cement Length after POOH: | 250.0 ft | | |




## Fluid Placement in Annulus

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.0 | 1017.2 | 1017.2 | 52.4 | 9.40 |
| MUDPUSH Express | 1017.2 | 1378.0 | 360.7 | 18.6 | 12.00 |
| G P2 | 1378.0 | 1651.5 | 273.5 | 15.7 | 15.80 |

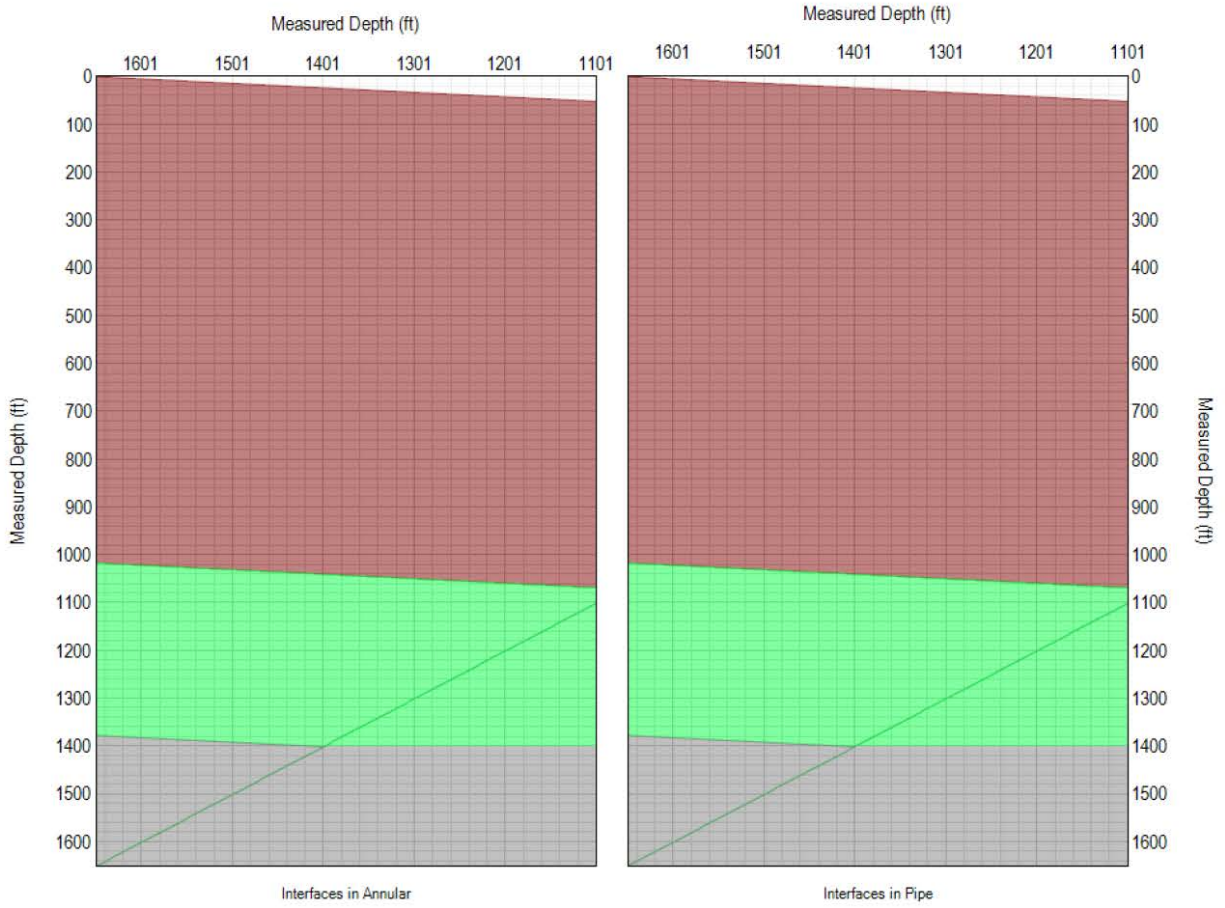
## Fluid Placement in Pipe

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.0 | 1017.2 | 1017.2 | 18.1 | 9.40 |
| MUDPUSH Express | 1017.2 | 1378.0 | 360.7 | 6.4 | 12.00 |
| G P2 | 1378.0 | 1651.5 | 273.5 | 4.9 | 15.80 |

# Static Pull Out Of Hole (POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP Depth: | 1101.5 ft | | Theoretical Top of Plug: | 1401.5 ft |
| POOH Length: | 550.0 ft | | Theoretical Plug Length: | 250.0 ft |
| POOH Speed: | 30-40ft/min | | Plug Bottom: | 1651.5 ft |
| **Top of uncontaminated cement after POOH:** | | | | **1401.5 ft** |
| **Uncontaminated cement length after POOH:** | | | | **250.0 ft** |
| Contaminated cement length after POOH: | | | | 0.0 ft |

## POOH Results Summary




Note: Simulation assumes that fluids are free to balance themselves.

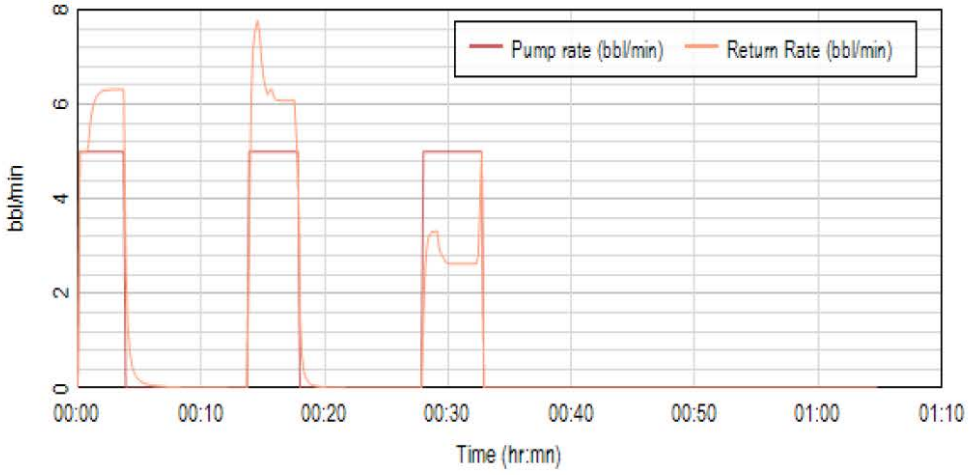
# Pumping Schedule

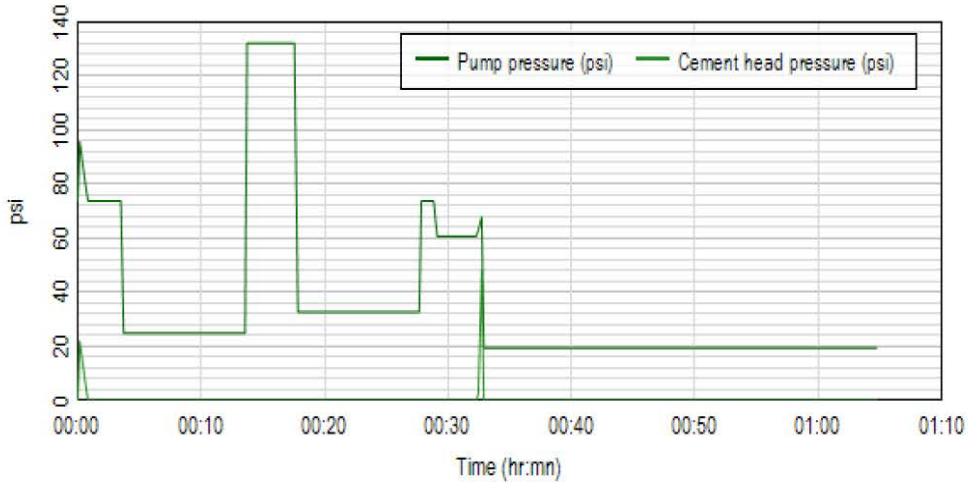
| Pumping Schedule | | | | | | |
|---|---|---|---|---|---|---|
| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Cum. Time hr:mn | Comment | Inj. Temp. degF |
| Pause | | | 00:00 | 00:00 | Circ to cool down well and cond mud 25min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.6 | 5.0 | 00:04 | 00:04 | | 80.0 |
| Plug | | | 00:10 | 00:14 | Foam ball | |
| G P2 | 20.6 | 5.0 | 00:04 | 00:18 | MinTT 2:51 | 80.0 |
| Plug | | | 00:10 | 00:28 | Foam ball | |
| MUDPUSH Express | 6.4 | 5.0 | 00:01 | 00:29 | | 80.0 |
| OBM | 18.1 | 5.0 | 00:04 | 00:33 | | 80.0 |
| Pause | | | 00:10 | 00:43 | Break cmt. lines | |
| Pause | | | 00:14 | 00:57 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:08 | 01:05 | Rig circ. pipe clean excess 60bbl @ 8bpm | |
| Pause | | | 00:00 | 01:05 | | |
| Shut-in | | | 00:00 | 01:05 | | |

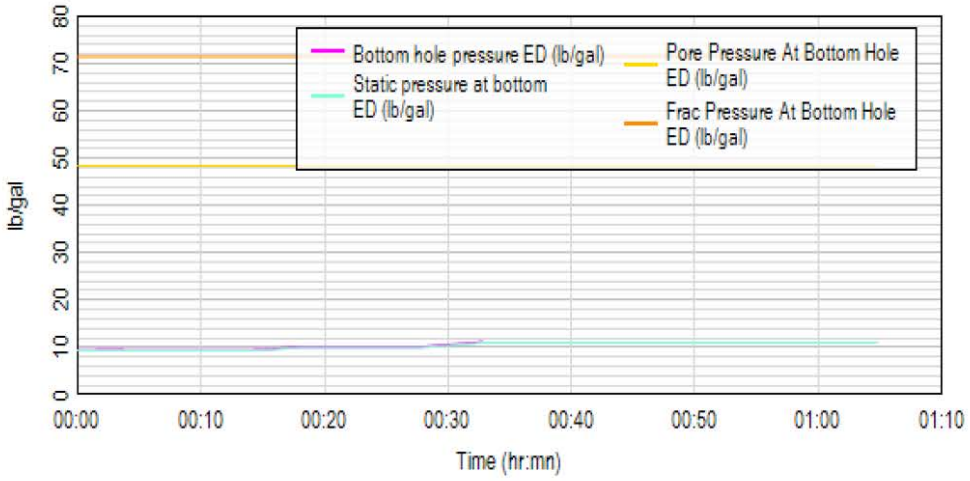
| | |
|---|---|
| Maximum Required Hydraulic Horsepower (HHP) | 16.2 hhp (at 00:14 hr:mn) |

| Displacement Volume Considerations | | |
|---|---|---|
| | Volume bbl | Variation bbl |
| Theoretical displacement volume | 18.1 | |
| Underdisplacement | | 0.0 |
| Final Displacement | 18.1 | |

Pauses in the jobs are only estimates – all efforts should be made during the operation to minimize these times.



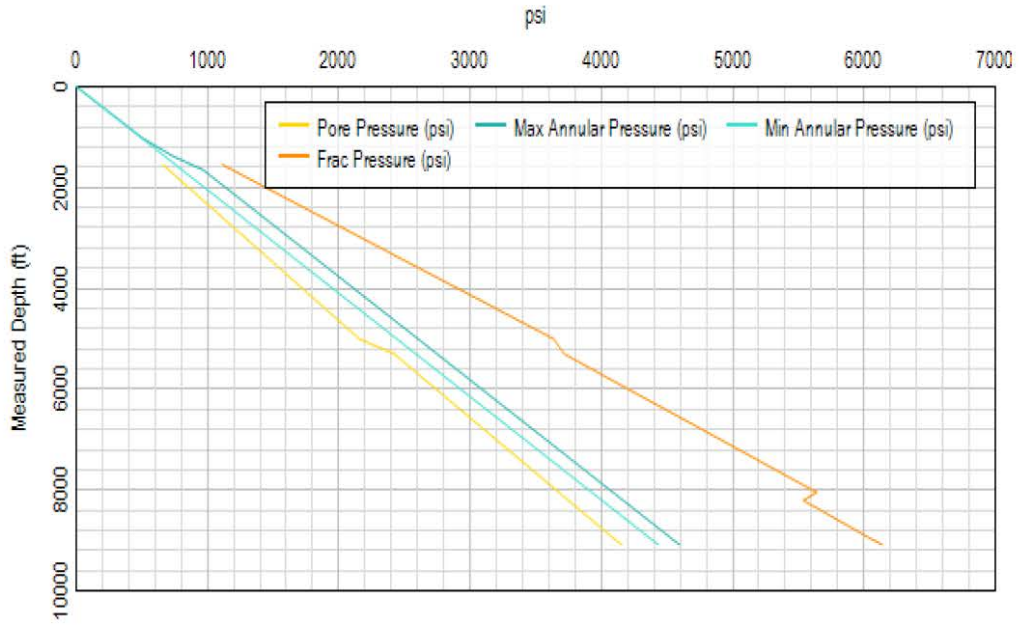

Pump pressure (psi)
Cement head pressure (psi)
psi
0
20
40
60
80
100
120
140
00:00
00:10
00:20
00:30
00:40
00:50
01:00
01:10
Time (hr:mn)


Bottom hole pressure ED (lb/gal)
Static pressure at bottom ED (lb/gal)
Pore Pressure At Bottom Hole ED (lb/gal)
Frac Pressure At Bottom Hole ED (lb/gal)
lb/gal
0
10
20
30
40
50
60
70
80
00:00
00:10
00:20
00:30
00:40
00:50
01:00
01:10
Time (hr:mn)

# Well Security

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 221 | 1651.5 | 00:33 |
| Success | Production/Influx | 96 | 1551.5 | 01:05 |
| Success | Burst | 9452 | 0.0 | 00:33 |
| Success | Collapse | 9704 | 607.0 | 00:18 |

## Well Control



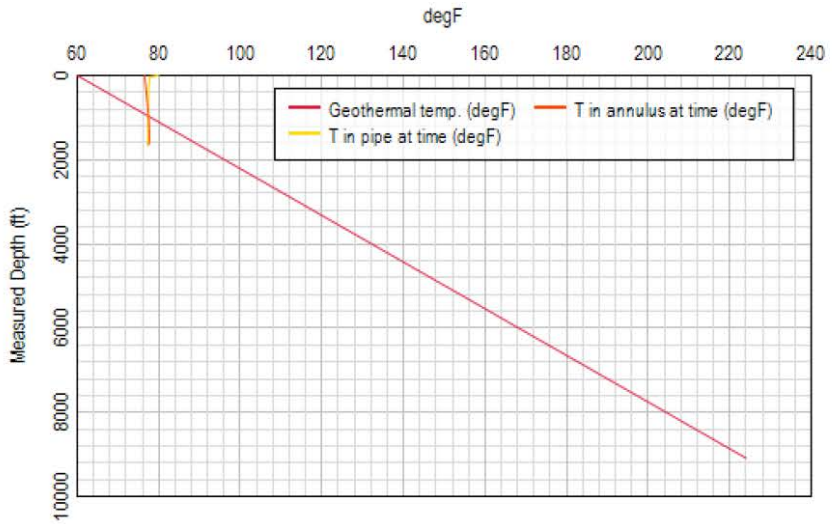
# Temperature Outputs

| | |
|---|---|
| BHST: | 89.8 degF |
| Static Temp at TOC: | 84.9 degF |

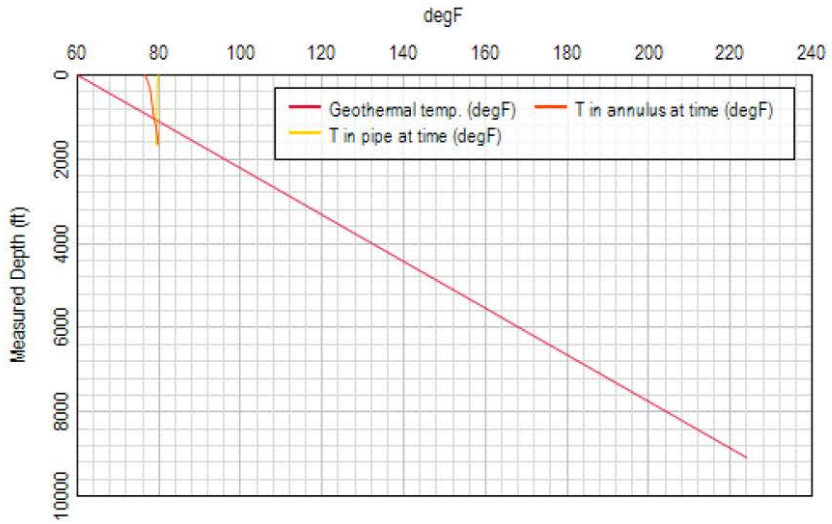
| | |
|---|---|
| Simulated BHCT: | 79.9 degF |
| Simulated HCT at TOC: | 79.5 degF |

Temperature simulation initial condition: Mud Circulation profile

## Initial Condition

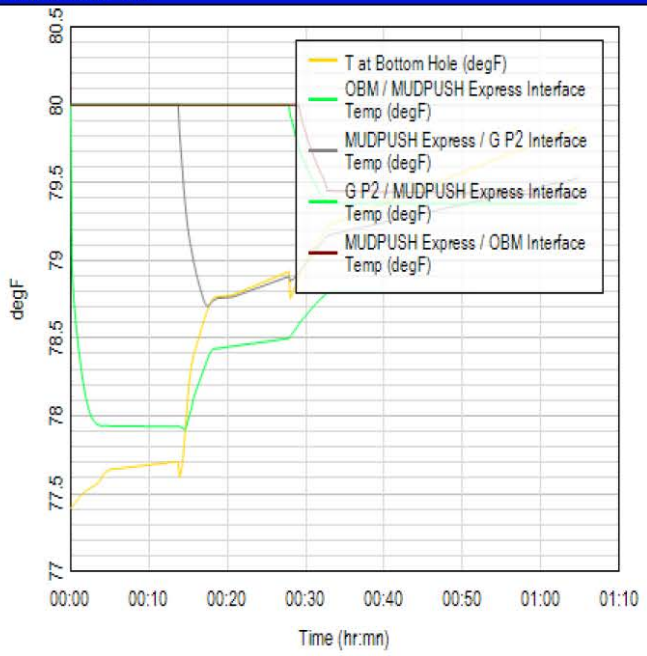



## Final Condition

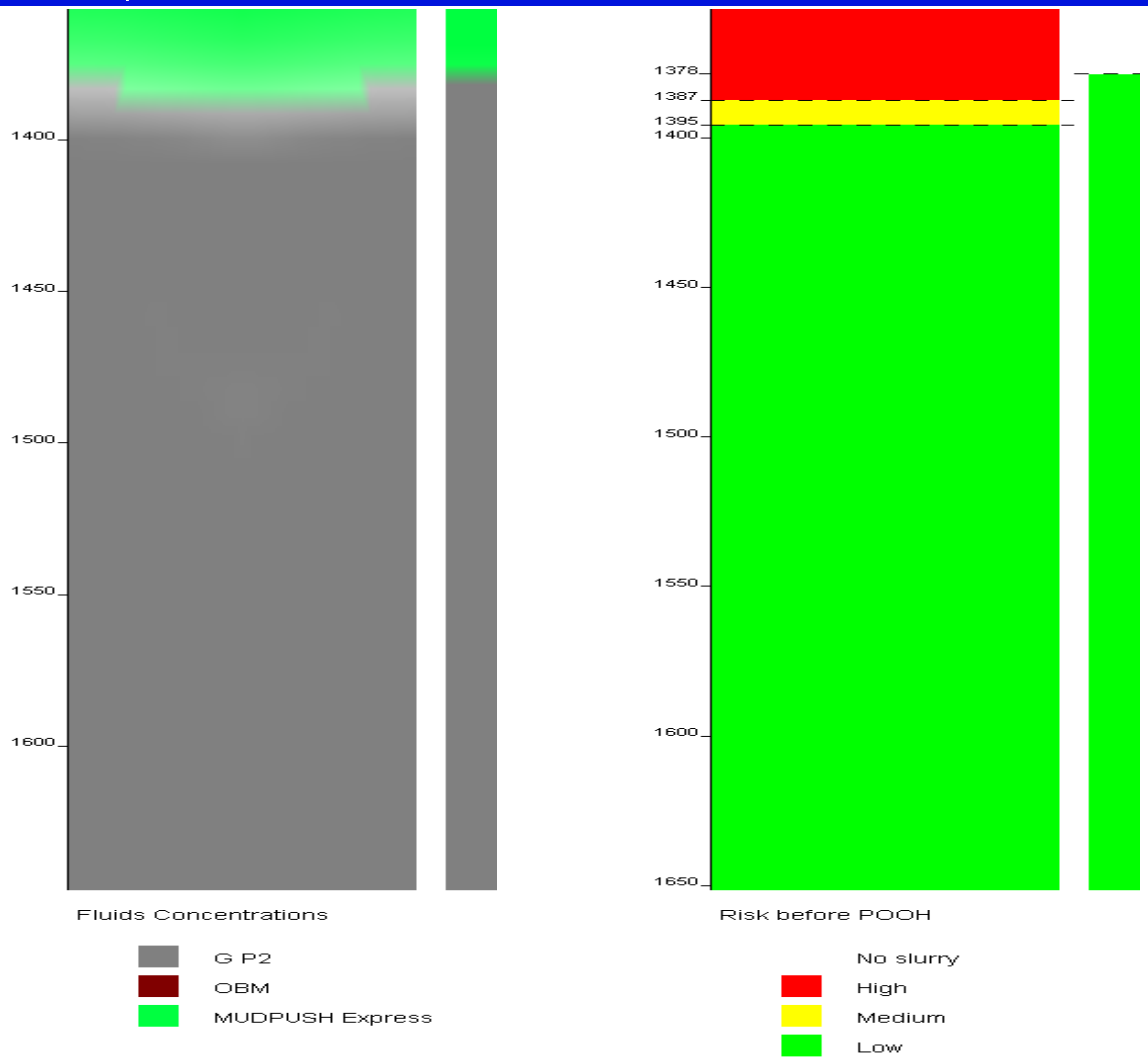



t = 01:05 hr:mn

## BHCT and Interface Temperatures



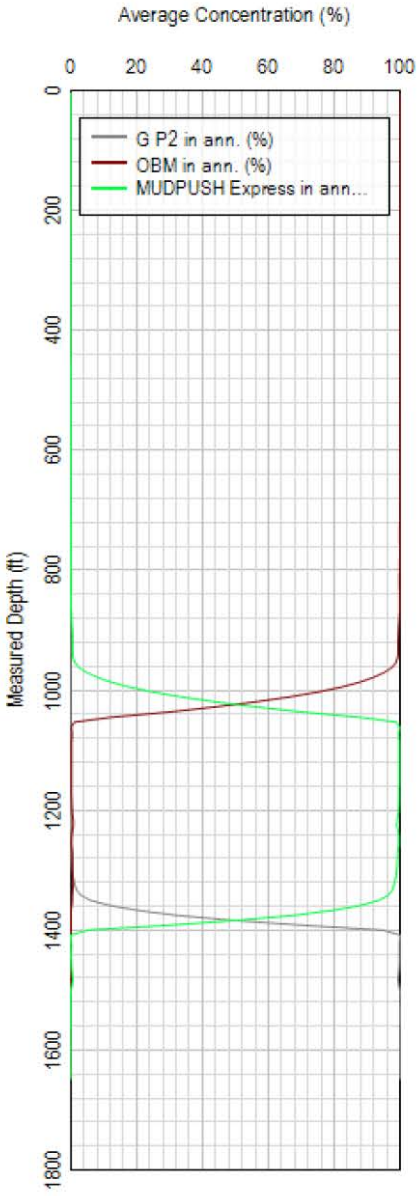
## WELLCLEAN III Maps



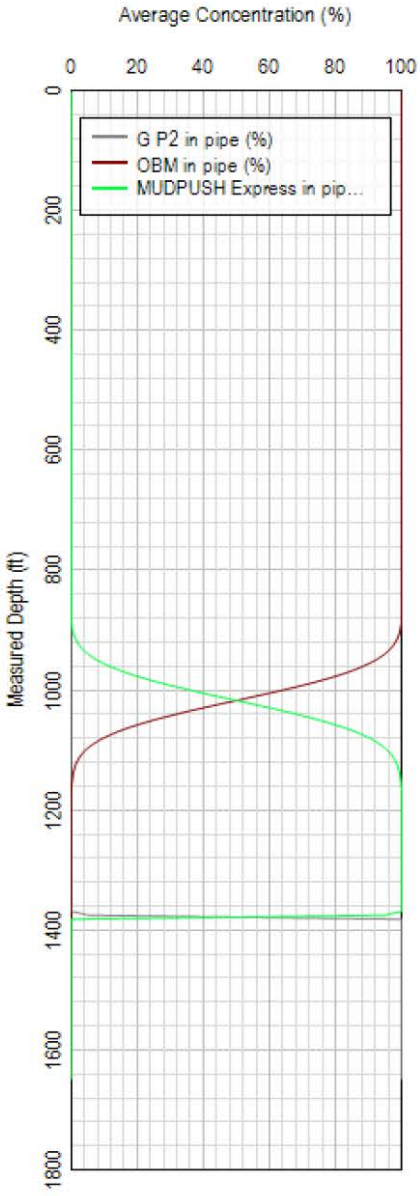

| | |
|---|---|
| **No cement slurry** | Slurry concentration is less than 10% (by unit of volume).<br>The concentration is below minimum threshold to consider that cement is present. |
| **High risk of contamination** | Slurry concentration is between 10% and 50% (by unit of volume).<br>There is no chance of finding hard cement when tagging within a few hours. |
| **Medium risk of contamination** | Slurry concentration is between 50% and 90% (by unit of volume).<br>It is possible to find some soft cement when tagging but it will most likely not be strong enough to kick off the well or even to provide a proper wellbore isolation. |
| **Low risk of contamination** | Slurry concentration is between 90% and 100% (by unit of volume).<br>Cement plug should be designed in such a way that the target of the top of cement should be within the 'green risk' zone. Hard cement should be found in that zone once compressive strength has developed, i.e. after the duration determined by the lab tests at downhole condition. |

## Fluid Concentrations before POOH

Average fluid concentration in annulus



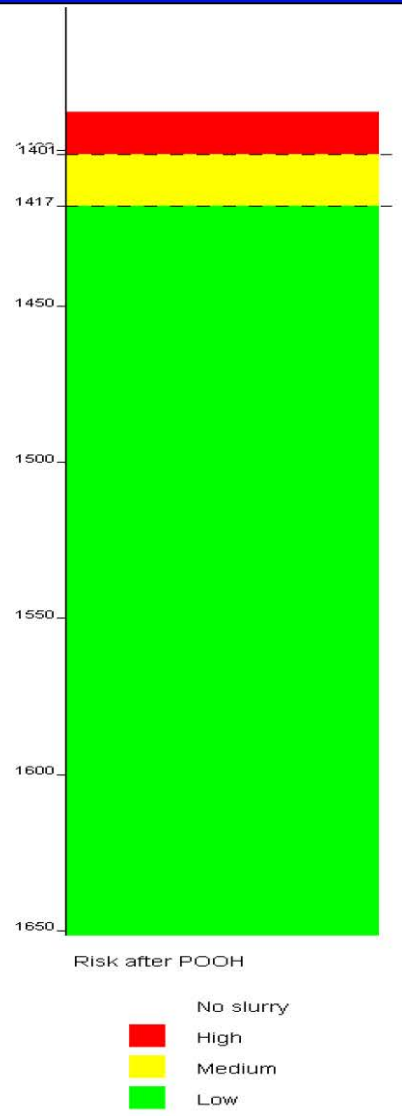

Average fluid concentration in pipe



# Final Contamination Risk (After POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP depth: | 1101.5 ft | | Theoretical Top of Plug: | 1401.5 ft |
| Theoretical Top of Plug (based on slurry volume) | | | | 1401.5 ft |
| Estimated TOC based on uncontaminated POOH simulation | | | | 1401.5 ft |
| Estimated TOC after POOH considering contamination during placement | | | | 1417.8 ft |

## Final Contamination Risk




Note: Simulation assumes that fluids are free to balance themselves

# Post-placement Circulation

Volume of compressible fluids is displayed at ambient conditions, ie. P = 1 atm and T = 60.0 degF

| | | | |
|---|---|---|---|
| DP Depth for Circulation: | 1101.5 ft | Designed TOC: | 1401.5 ft |

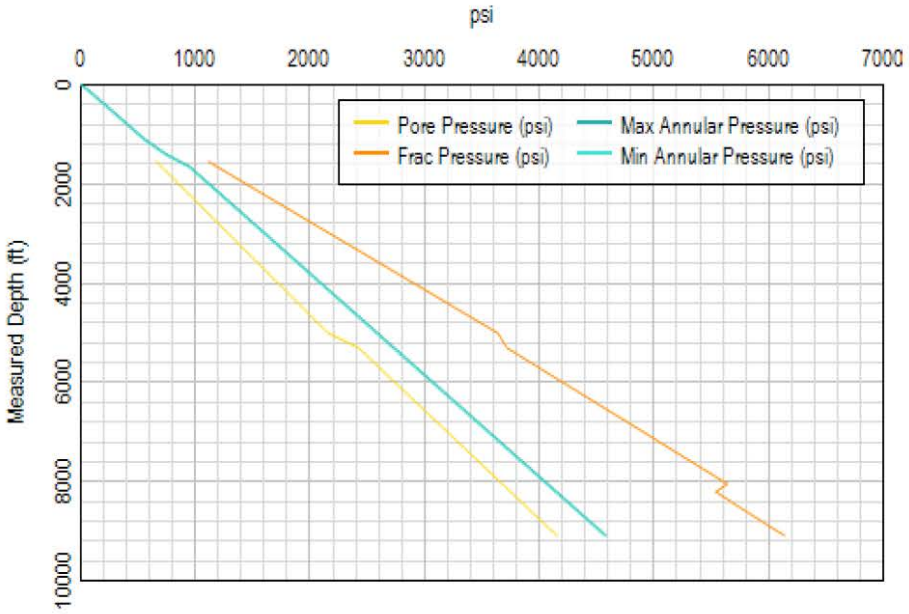
| | | | |
|---|---|---|---|
| Circulating Fluid: | OBM | Total Volume: | 60.0 bbl |
| Circulation Direction: | Direct | Number of Circulations: | 0.786 |

## Circulation Stages

| Stage | Pump Rate bbl/min | Duration hr:mn | Volume bbl | Back-pressure psi |
|---|---|---|---|---|
| OBM | 8.0 | 00:08 | 60.0 | 0 |

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 234 | 1642.8 | 00:07 |
| Success | Production/Influx | 195 | 1551.5 | 00:08 |
| Success | Burst | 9449 | 0.0 | 00:07 |
| Success | Collapse | 9920 | 1101.5 | 00:00 |

## Post-Placement Well Control






# Cypress M2 Isolation Plug

version 5 plug 3

1/22/2024

Rig : True Drilling 38

Prepared for:
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Prepared by:
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# Job Objectives and Design Considerations

## Job Objectives

Mud company to spot 500' viscous pill below 3519' prior cement operations to support plug.
Circ. to cool down well and condition mud as per schedule.
Cement balanced plug, Isolation plug from 3519-3419' (100' plug length) in 8 3/4" OH (5% over caliper), no plan of tagging (expected TOC ~3439'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (3119') @ 40'/min rotating pipe slow and circulate to clean out excess.

## Acceptance Criteria

Pump plug as per design

### Operational Risk Statement

Cement plugs operations are complex to design and execute and this complexity should not be underestimated. Cement plugs operations should never be considered as a "routine" job. To successfully set cement plugs the same methodology used to design and execute primary cement jobs is required, which includes but is not limited to correct slurry design, mud-removal and placement design based on accurate well data. Cement plugs are remedial cementing treatments. The first design step is the determination of the actual problem to solve, i.e. define the purpose of setting a cement plug. The second step consists in defining the evaluation criteria: tag / no tag, positive pressure test, negative test, etc. Both steps allow for the proper specification of slurry properties and the determination of the adequate plug placement technique. This can result in additional laboratory tests as well as additional equipment requirements.

Nelson in Well Cementing (2006) discusses several factors that are key to successful plug cementing operations.
Displacement and under-displacement volumes play a critical role for the success of the job. The volumes specified in this program should be followed.
Fluid contamination/mixing during plug setting can jeopardize job success. To mitigate this risk, using a stable base for the plug, mechanical separators, and appropriate wait-on-cement-time is strongly recommended.
In case of a Kick-off Plug, proper knowledge of the BHA and application of correct drilling techniques are required to kick-off.

In case of any deviation from the approved job procedure, a Management of Change (MoC) is required. By raising a MoC to the appropriate level within the operator organization as well as within SLB, all the operational risks can be identified and addressed prior to execution of the cement plug.

# Plug Operation Summary

Overview of the cementing operation (temperatures, fluid types, rates and general notes)
**All depths (except water depth) take the rig floor as reference**

## Well & Rig Information

| | |
|---|---|
| Rig Type: | Land |

Objective: Mud company to spot 500' viscous pill below 3519' prior cement operations to support plug.
Circ. to cool down well and condition mud as per schedule.
Cement balanced plug, Isolation plug from 3519-3419' (100' plug length) in 8 3/4" OH (5% over caliper), no plan of tagging (expected TOC ~3439'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (3119') @ 40'/min rotating pipe slow and circulate to clean out excess.

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |
| Well Deviation: | 0.0 deg |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Placement & Post-Placement Conditions

| | |
|---|---|
| **Top:** | **3419.0 ft** |
| Length: | 100.0 ft |
| **Bottom:** | **3519.0 ft** |
| **Support:** | **VISCOUS PILL** |

| | |
|---|---|
| Mechanical Separator: | AHEAD AND BEHIND |
| Pipe Rotation / Reciprocation: | ROTATION |

| | |
|---|---|
| POOH Depth: | 3119.0 ft |
| POOH Speed: | 30-40FT/MIN |
| Circ. Rate: | 8.0 bbl/min |
| Circ. Direction: | Direct |

| | |
|---|---|
| String type and configuration: | OPEN ENDED |

## Design Considerations

| G P3 | |
|---|---|
| Cement Type: | Slurry |
| Slurry Dens.: | 15.80 lb/gal |

| MUDPUSH Express | |
|---|---|
| Spacer Type: | Spacer |
| Spacer Dens.: | 12.00 lb/gal |

| OBM | |
|---|---|
| Mud Type: | Oil Based Mud |
| Mud Dens.: | 9.40 lb/gal |

| | | | |
|---|---|---|---|
| **Volume Balance Model:** | Optimize Slurry & Spacer | Underdispl.: | 0.0 bbl |

## Pumping Schedule

| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Comment | Inj. Temp. degF |
|---|---|---|---|---|---|
| Pause | | | 00:00 | Circ to cool down well and cond mud 60min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.9 | 5.0 | 00:04 | | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| G P3 | 7.9 | 5.0 | 00:02 | MinTT 3:10 | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| MUDPUSH Express | 6.1 | 5.0 | 00:01 | | 80.0 |
| OBM | 54.4 | 5.0 | 00:11 | | 80.0 |
| Pause | | | 00:10 | Break cmt. lines | |



| | | | | | |
|---|---|---|---|---|---|
| Pause | | | 00:13 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:23 | Rig circ. pipe clean excess 182bbl @ 8bpm | |
| Pause | | | 00:00 | | |
| Shut-in | | | 00:00 | | |

| Temperature Simulation | | | | |
|---|---|---|---|---|
| Pre-job Circ. Rate: | 8 bbl/min | | BHST: | 123.6 degF |
| Pre-job Circ. Time: | 60MIN | | Simulated BHCT: | 93.2 degF |

# Well Data Summary

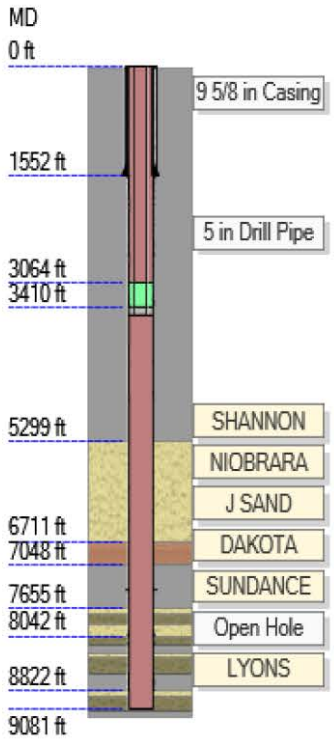
The cementing program incorporates the following data:
**All depths (except water depth) take the rig floor as reference**

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Tubulars and Casing Hardware

| | MD ft | OD in | Weight lb/ft | Grade | ID in | Thread | Collapse psi | Burst psi | Joint ft |
|---|---|---|---|---|---|---|---|---|---|
| Prev Casing | 1551.5 | 9 5/8 | 40.0 | J-55 | 8.835 | | 2570 | 3950 | 1.0 |
| Workstring | 3519.0 | 5 | 19.5 | E75 | 4.276 | | 10000 | 9500 | 40.0 |



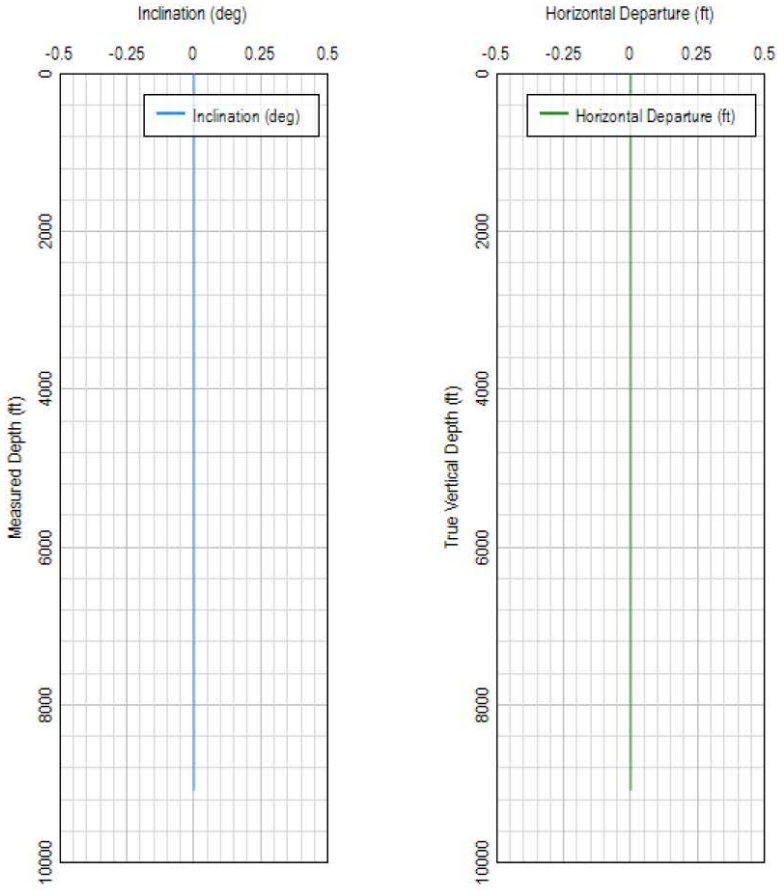

## Open Hole

| | |
|---|---|
| Total OH Volume: | 588.0 bbl |
| Minimum Diameter: | 8.473 in |
| Maximum Diameter: | 12.776 in |

| | |
|---|---|
| Mean Diameter: | 8.750 in |
| Mean Ann. Excess: | 0.000 % |
| Mean Eq. Diameter: | 8.966 in |

Note : OH caliper was uploaded.

## Directional Survey




**Note:** Hole assumed vertical

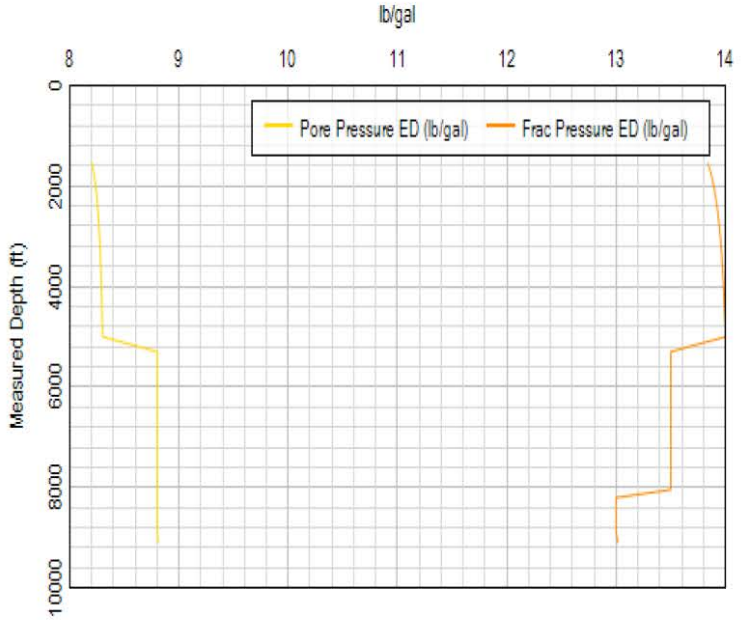
## Formation

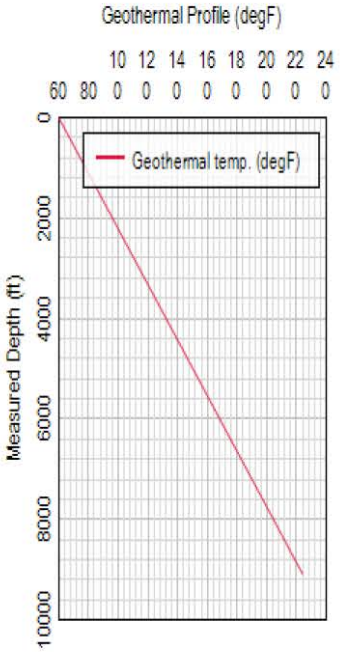
| Top MD ft | Bottom MD ft | Bottom TVD ft | Frac Top ED lb/gal | Frac Bottom ED lb/gal | Pore Top ED lb/gal | Pore Bottom ED lb/gal | Lithology | Res. Fluid | Name |
|---|---|---|---|---|---|---|---|---|---|
| 25.5 | 5000.0 | 5000.0 | 0.00 | 14.00 | 0.00 | 8.30 | | | |
| 5000.0 | 5299.0 | 5299.0 | 14.00 | 13.50 | 8.30 | 8.80 | | | |
| 5299.0 | 6711.0 | 6711.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | SHANNON |
| 6711.0 | 7048.0 | 7048.0 | 13.50 | 13.50 | 8.80 | 8.80 | Shale | | NIOBRARA |
| 7048.0 | 7250.0 | 7250.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7250.0 | 7655.0 | 7655.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7655.0 | 7734.0 | 7734.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | J SAND |
| 7734.0 | 7894.0 | 7894.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7894.0 | 8042.0 | 8042.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | DAKOTA |
| 8042.0 | 8200.0 | 8200.0 | 13.50 | 13.00 | 8.80 | 8.80 | | | |
| 8200.0 | 8274.0 | 8274.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8274.0 | 8336.0 | 8336.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | SUNDANCE |
| 8336.0 | 8500.0 | 8500.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8500.0 | 8600.0 | 8600.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8600.0 | 8682.0 | 8682.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8682.0 | 8822.0 | 8822.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8822.0 | 8891.0 | 8891.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | LYONS |
| 8891.0 | 9081.0 | 9081.0 | 13.00 | 13.01 | 8.80 | 8.81 | | | |

## Temperature

| Name | Top MD ft | Bottom MD ft | Bottom TVD ft | Temp. degF | Temp. Gradient degF/100ft | Temp. Rel. Gradient degF/100ft | |
|---|---|---|---|---|---|---|---|
| Surface | 0.0 | 0.0 | 0.0 | 60.0 | 0.00 | | |
| Rock | 0.0 | 3419.0 | 3419.0 | 121.7 | 1.81 | 1.81 | |
| BHST | 3419.0 | 3519.0 | 3519.0 | 123.6 | 1.81 | 1.81 | |
| Rock | 3519.0 | 5386.0 | 5386.0 | 157.3 | 1.81 | 1.81 | |
| Rock | 5386.0 | 9081.0 | 9081.0 | 224.0 | 1.81 | 1.81 | |

**Source of temperature data:** 224degF at BH from 3 different SLB WL Logs, confirmed with client

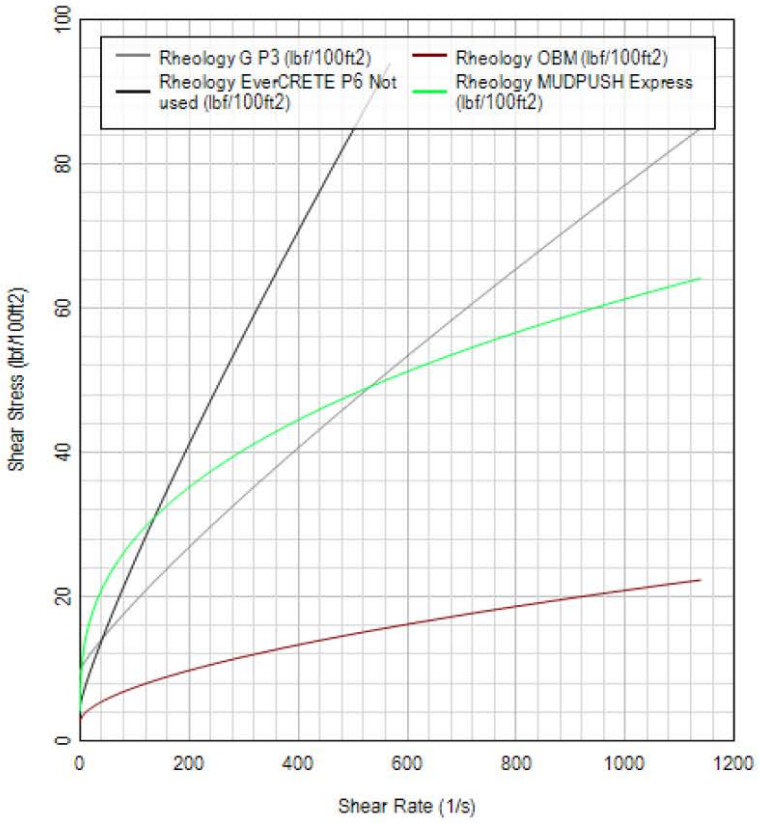


# Fluids Summary

| Fluids | | | | | | |
|---|---|---|---|---|---|---|
| Type | Name | Density lb/gal | Conditions | K lbf.s^n/ft2 | n | Ty lbf/100ft2 |
| Drilling Fluid | OBM | 9.40 | Downhole 190.0 degF | 3.03E-3 | 0.589 | 2.59 |
| Spacer | MUDPUSH Express | 12.00 | Downhole 190.0 degF WND 2023-153 | 3.94E-2 | 0.381 | 4.10 |
| Slurry | G P3 | 15.80 | Downhole 171.0 degF CWY 2022-301 | 1.86E-3 | 0.852 | 9.20 |

* Rheology and density of compressible fluids are displayed at standard conditions, ie. P = 1 atm and T = 20 degC (65 degF)




| Fluid Density and Rheology Tolerance |
|---|
| **Mud** – properties to be verified prior to job with mud engineer, contact engineer onshore if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg rheology difference from planned : +/- 10% |
| **Spacer** – properties to be verified prior to job, see contingency plans if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg |
| **Slurry** – cement slurry should be mixed within the range described below, see contingency plans if there is mismatch between designed density and slurry volume<br>density difference from planned : +/- 0.2 ppg |

# Mud Circulation

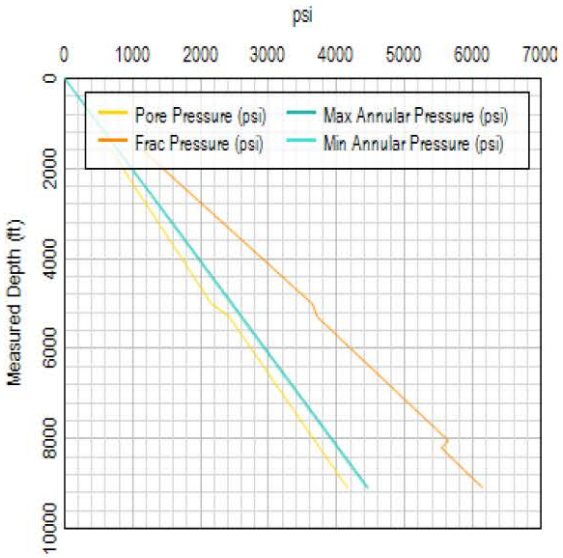
| | |
|---|---|
| Fluid | OBM |
| Number of Circulations | 1.908 |
| Total Volume at Ambient Temperature | 480.0 bbl |
| Ambient Temperature | 80.0 degF |
| Correction Slope | 0.700 |

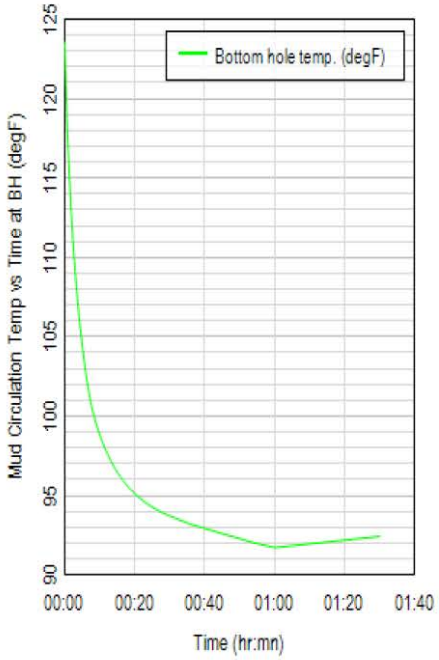
**Pumping Stages**

| Fluid | Pump Rate bbl/min | Duration hr:mn | Volume bbl |
|---|---|---|---|
| OBM | 8.0 | 01:00 | 480.0 |
| Pause | | 00:30 | |

**Well Security**

| Status | Description | Min Differential Pressure psi | At Depth ft | At Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 346 | 1551.5 | 01:00 |
| Success | Production/Influx | 96 | 1551.5 | 01:30 |
| Success | Burst | 9392 | 0.0 | 00:00 |
| Success | Collapse | 9751 | 3519.0 | 01:30 |



# Fluid Placement

## Volume Balance Objectives

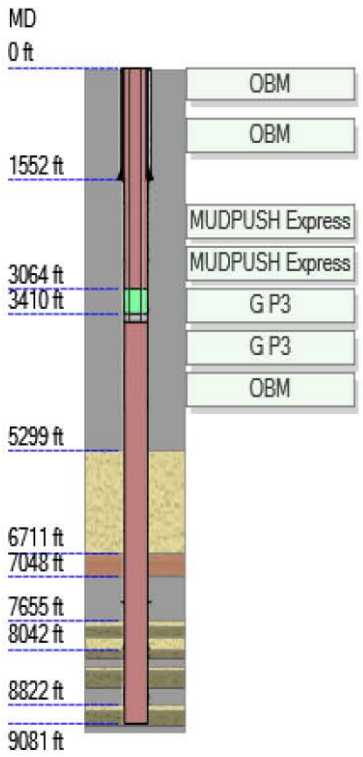
Volume Balance Model: **Optimize Slurry & Spacer**

| | | | | | |
|---|---|---|---|---|---|
| Original Fluid: | OBM | Rat Hole Fluid: | OBM | Displ. Fluid: | OBM |
| Top Spacer: | MUDPUSH Express | set Total Volume to: | 25.0 bbl | | |
| Top Slurry: | G P3 | set Top MD to: | 3419.0 ft | | |

Annulus is **not** filled during POOH.

## Volume Balance Results

| | | | | | |
|---|---|---|---|---|---|
| String Volume: | 62.5 bbl | Underdispl.: | 0.0 bbl | Displ. Volume: | 54.4 bbl |
| TOC after POOH: | 3419.0 ft | Cement Length after POOH: | 100.0 ft | | |




## Fluid Placement in Annulus

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.0 | 3065.3 | 3065.3 | 164.3 | 9.40 |
| MUDPUSH Express | 3065.3 | 3410.0 | 344.7 | 18.9 | 12.00 |
| G P3 | 3410.0 | 3519.0 | 109.0 | 5.9 | 15.80 |

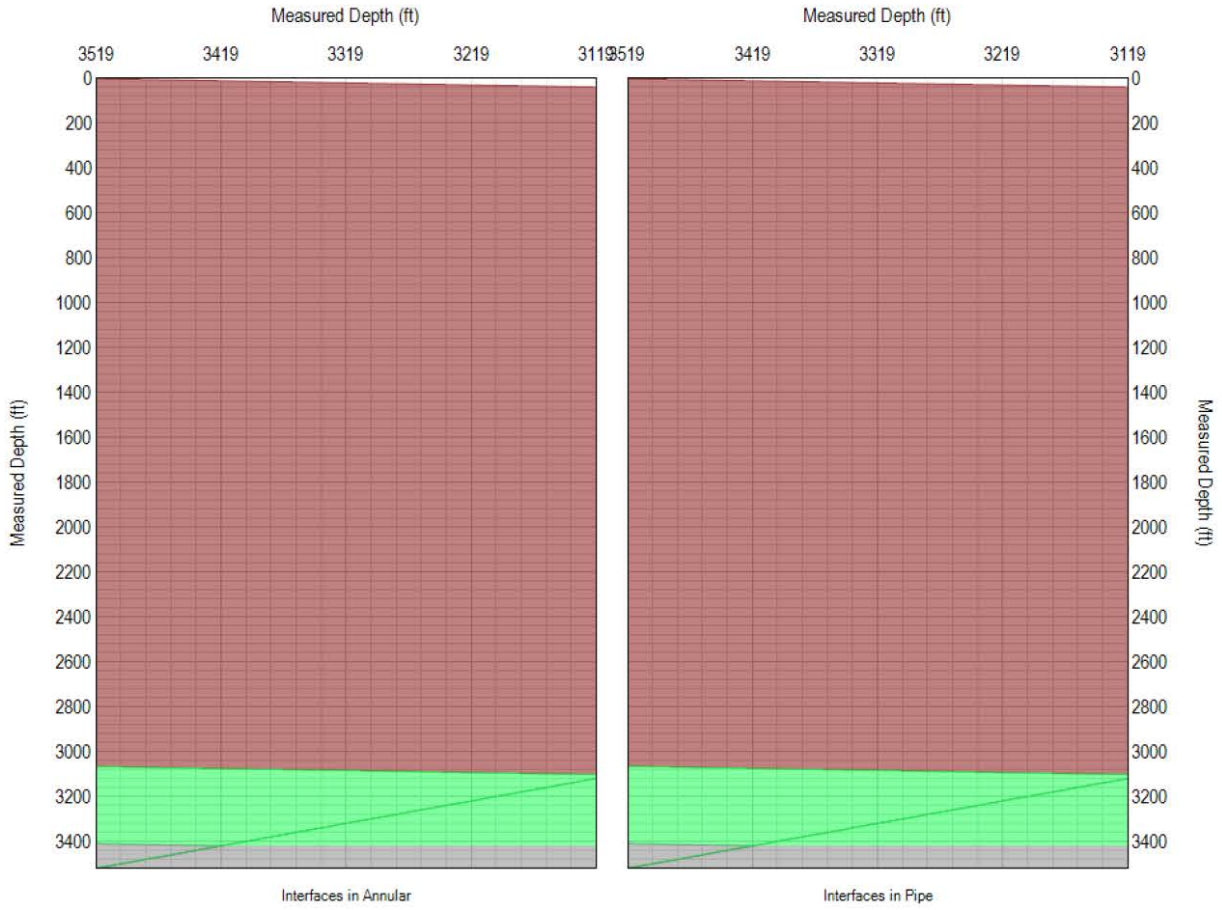
## Fluid Placement in Pipe

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.4 | 3064.2 | 3063.8 | 54.4 | 9.40 |
| MUDPUSH Express | 3064.2 | 3409.7 | 345.5 | 6.1 | 12.00 |
| G P3 | 3409.7 | 3519.0 | 109.3 | 1.9 | 15.80 |

# Static Pull Out Of Hole (POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP Depth: | 3119.0 ft | | Theoretical Top of Plug: | 3419.0 ft |
| POOH Length: | 400.0 ft | | Theoretical Plug Length: | 100.0 ft |
| POOH Speed: | 30-40ft/min | | Plug Bottom: | 3519.0 ft |
| **Top of uncontaminated cement after POOH:** | | | | **3419.0 ft** |
| **Uncontaminated cement length after POOH:** | | | | 100.0 ft |
| Contaminated cement length after POOH: | | | | 0.0 ft |

## POOH Results Summary




Note: Simulation assumes that fluids are free to balance themselves.

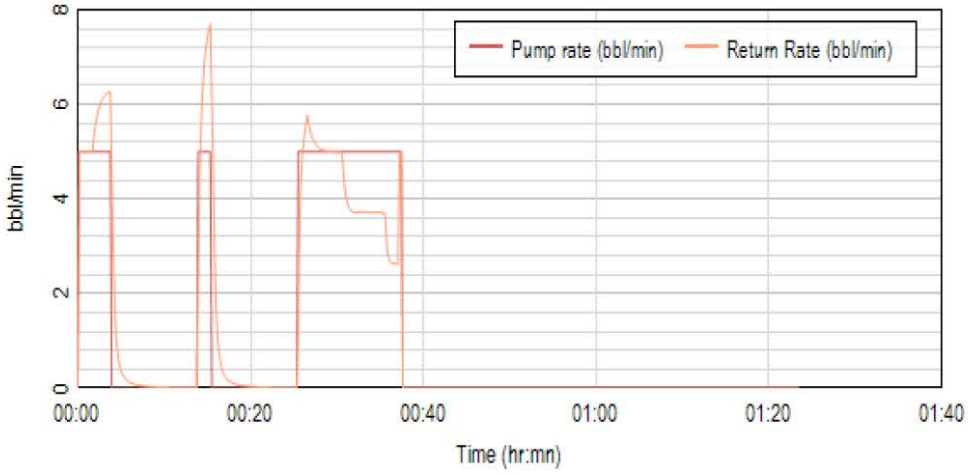
# Pumping Schedule

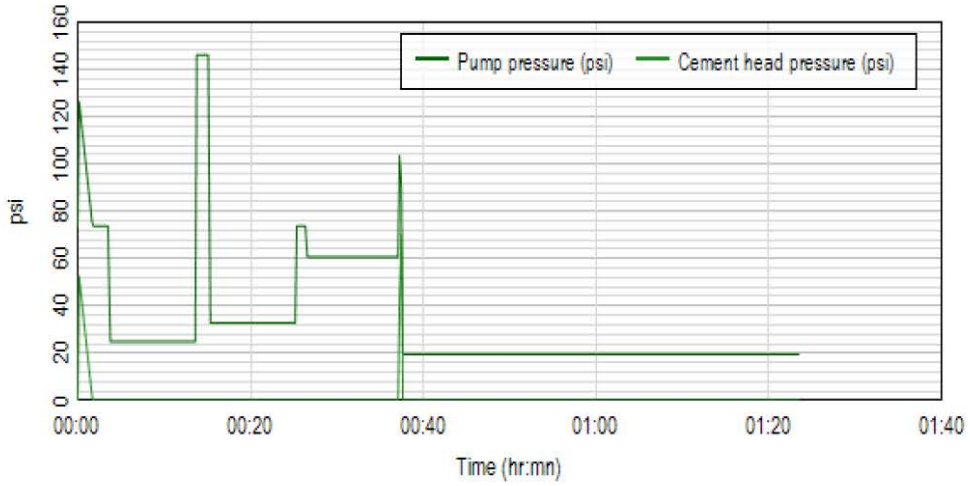
| Pumping Schedule | | | | | | |
|---|---|---|---|---|---|---|
| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Cum. Time hr:mn | Comment | Inj. Temp. degF |
| Pause | | | 00:00 | 00:00 | Circ to cool down well and cond mud 60min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.9 | 5.0 | 00:04 | 00:04 | | 80.0 |
| Plug | | | 00:10 | 00:14 | Foam ball | |
| G P3 | 7.9 | 5.0 | 00:02 | 00:15 | MinTT 3:10 | 80.0 |
| Plug | | | 00:10 | 00:25 | Foam ball | |
| MUDPUSH Express | 6.1 | 5.0 | 00:01 | 00:27 | | 80.0 |
| OBM | 54.4 | 5.0 | 00:11 | 00:37 | | 80.0 |
| Pause | | | 00:10 | 00:47 | Break cmt. lines | |
| Pause | | | 00:13 | 01:00 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:23 | 01:23 | Rig circ. pipe clean excess 182bbl @ 8bpm | |
| Pause | | | 00:00 | 01:23 | | |
| Shut-in | | | 00:00 | 01:23 | | |

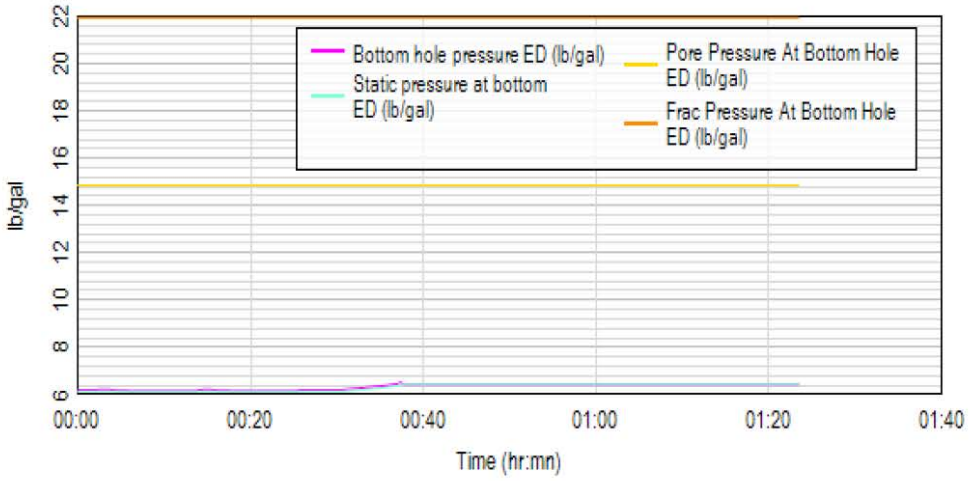
| | |
|---|---|
| Maximum Required Hydraulic Horsepower (HHP) | 17.9 hhp (at 00:14 hr:mn) |

| Displacement Volume Considerations | | |
|---|---|---|
| | Volume bbl | Variation bbl |
| Theoretical displacement volume | 54.4 | |
| Underdisplacement | | 0.0 |
| Final Displacement | 54.4 | |

Pauses in the jobs are only estimates – all efforts should be made during the operation to minimize these times.



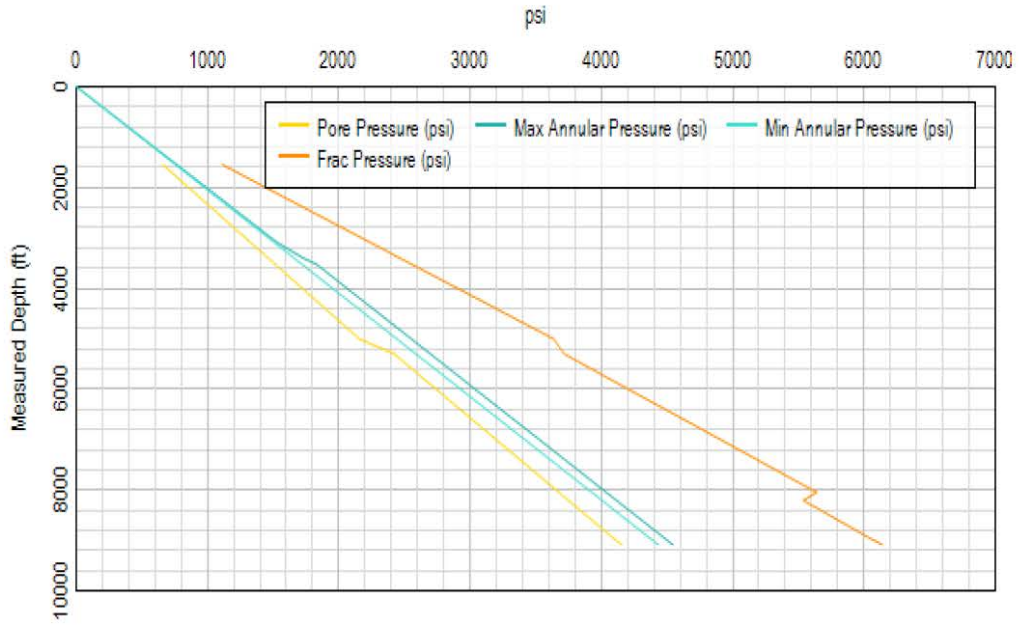

Pump pressure (psi)
Cement head pressure (psi)
psi
0
20
40
60
80
100
120
140
160
00:00
00:20
00:40
01:00
01:20
01:40
Time (hr:mn)


Bottom hole pressure ED (lb/gal)
Static pressure at bottom ED (lb/gal)
Pore Pressure At Bottom Hole ED (lb/gal)
Frac Pressure At Bottom Hole ED (lb/gal)
lb/gal
6
8
10
12
14
16
18
20
22
00:00
00:20
00:40
01:00
01:20
01:40
Time (hr:mn)

# Well Security

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 347 | 1551.5 | 00:15 |
| Success | Production/Influx | 96 | 1551.5 | 01:23 |
| Success | Burst | 9430 | 0.0 | 00:37 |
| Success | Collapse | 9597 | 1706.0 | 00:30 |

## Well Control



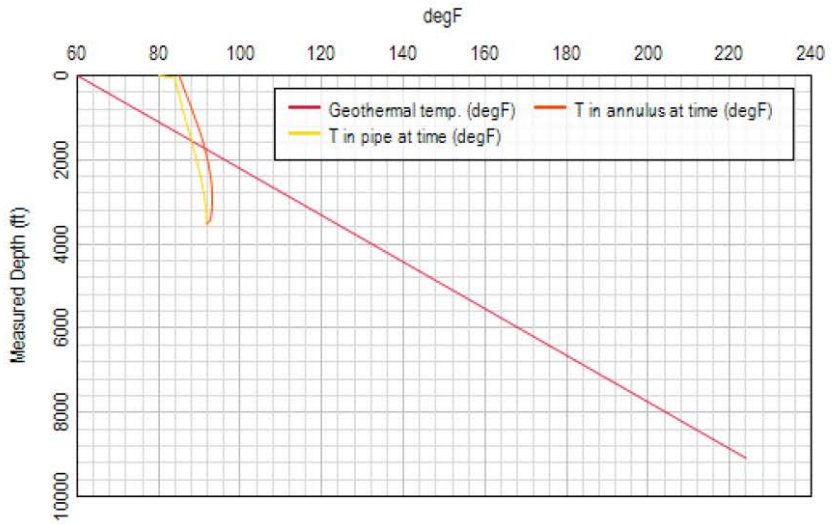
# Temperature Outputs

| | |
|---|---|
| BHST: | 123.6 degF |
| Static Temp at TOC: | 121.6 degF |

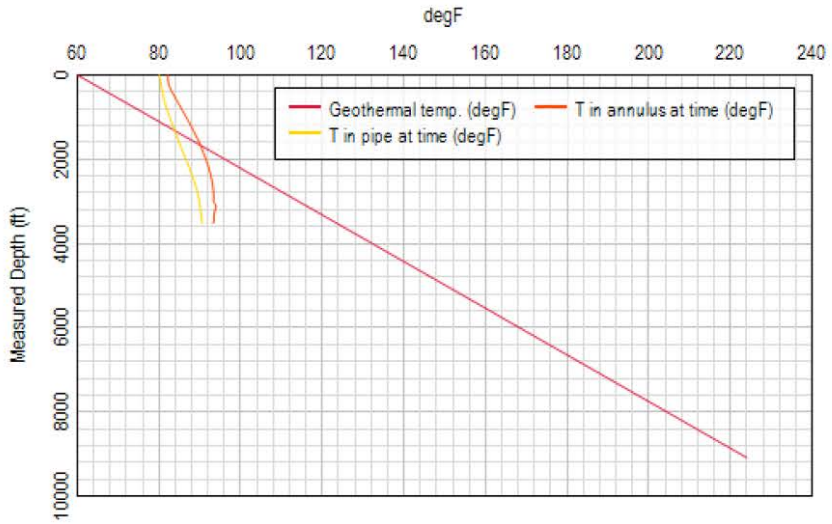
| | |
|---|---|
| Simulated BHCT: | 93.2 degF |
| Simulated HCT at TOC: | 93.3 degF |

Temperature simulation initial condition: Mud Circulation profile

## Initial Condition

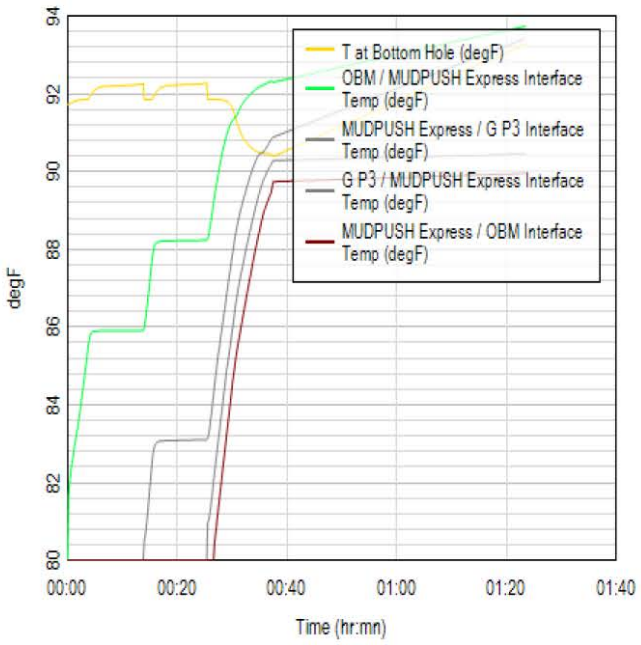



## Final Condition

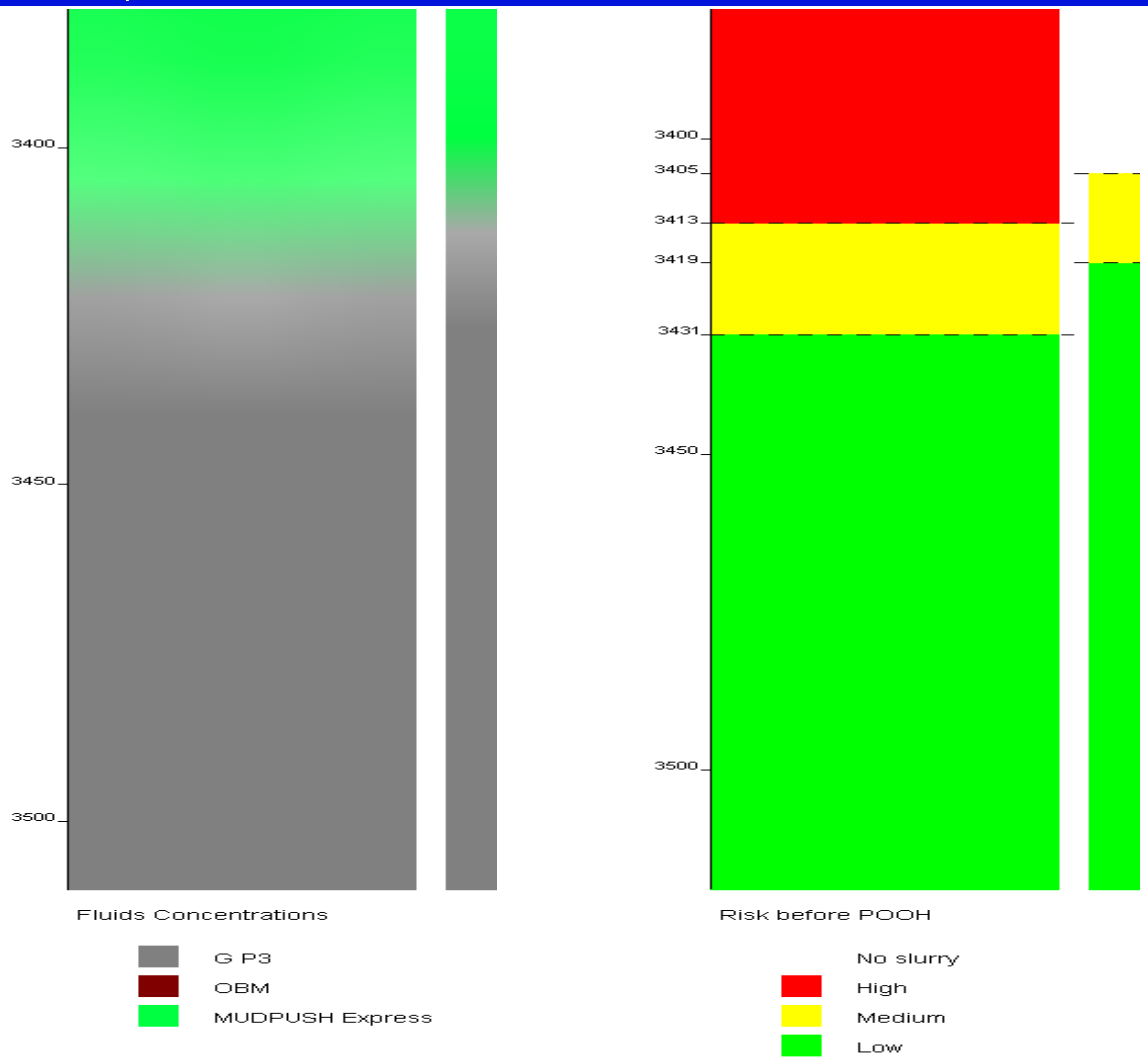



t = 01:23 hr:mn

## BHCT and Interface Temperatures



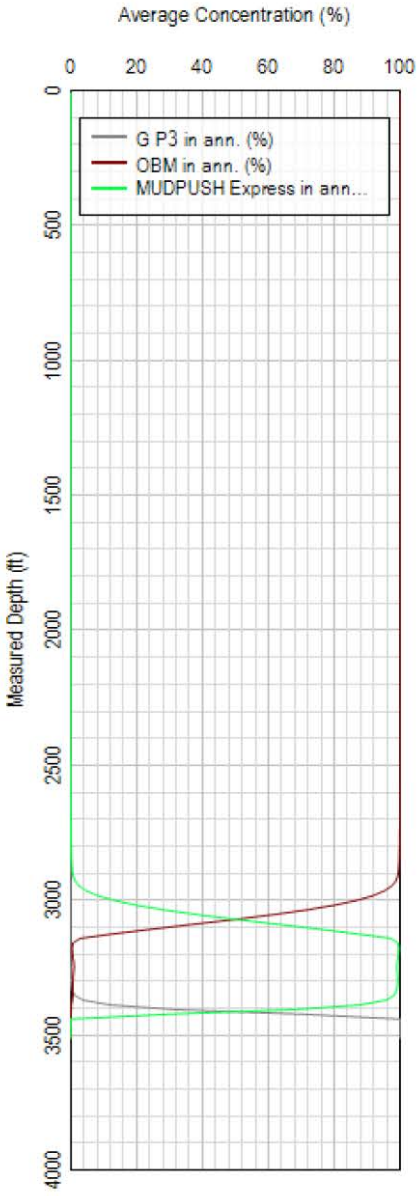
## WELLCLEAN III Maps



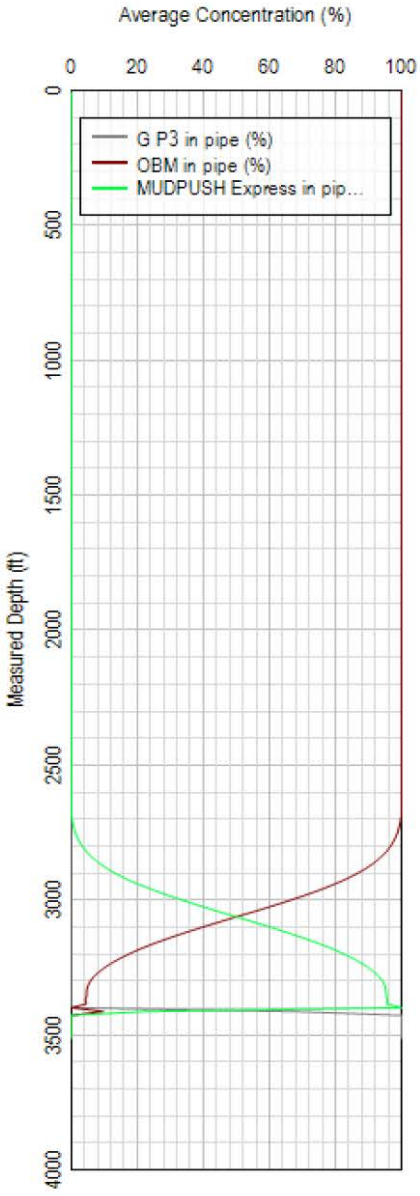

| | |
|---|---|
| **No cement slurry** | Slurry concentration is less than 10% (by unit of volume).<br>The concentration is below minimum threshold to consider that cement is present. |
| **High risk of contamination** | Slurry concentration is between 10% and 50% (by unit of volume).<br>There is no chance of finding hard cement when tagging within a few hours. |
| **Medium risk of contamination** | Slurry concentration is between 50% and 90% (by unit of volume).<br>It is possible to find some soft cement when tagging but it will most likely not be strong enough to kick off the well or even to provide a proper wellbore isolation. |
| **Low risk of contamination** | Slurry concentration is between 90% and 100% (by unit of volume).<br>Cement plug should be designed in such a way that the target of the top of cement should be within the 'green risk' zone. Hard cement should be found in that zone once compressive strength has developed, i.e. after the duration determined by the lab tests at downhole condition. |

## Fluid Concentrations before POOH

Average fluid concentration in annulus




Average fluid concentration in pipe

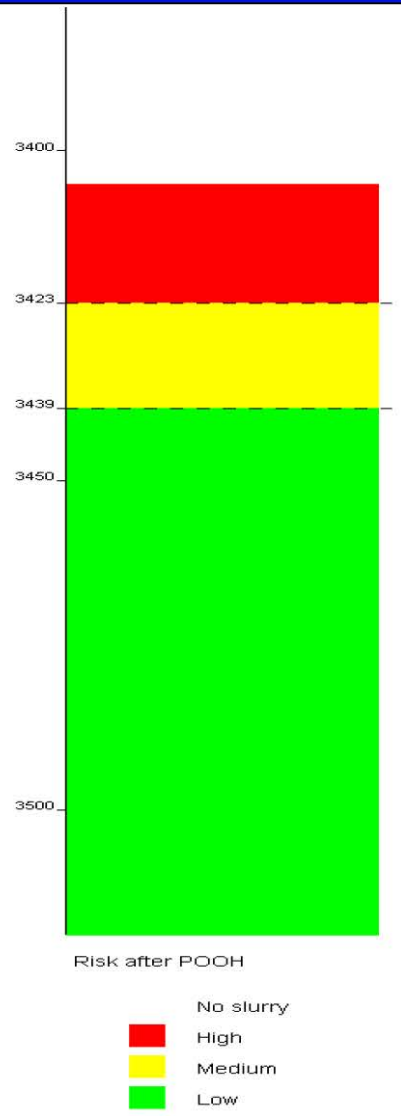


# Final Contamination Risk (After POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP depth: | 3119.0 ft | | Theoretical Top of Plug: | 3419.0 ft |

| | |
|---|---|
| Theoretical Top of Plug (based on slurry volume) | 3419.0 ft |
| Estimated TOC based on uncontaminated POOH simulation | 3419.0 ft |
| Estimated TOC after POOH considering contamination during placement | 3439.0 ft |

## Final Contamination Risk




Note: Simulation assumes that fluids are free to balance themselves

# Post-placement Circulation

Volume of compressible fluids is displayed at ambient conditions, ie. P = 1 atm and T = 60.0 degF

| | | | |
|---|---|---|---|
| DP Depth for Circulation: | 3119.0 ft | Designed TOC: | 3419.0 ft |

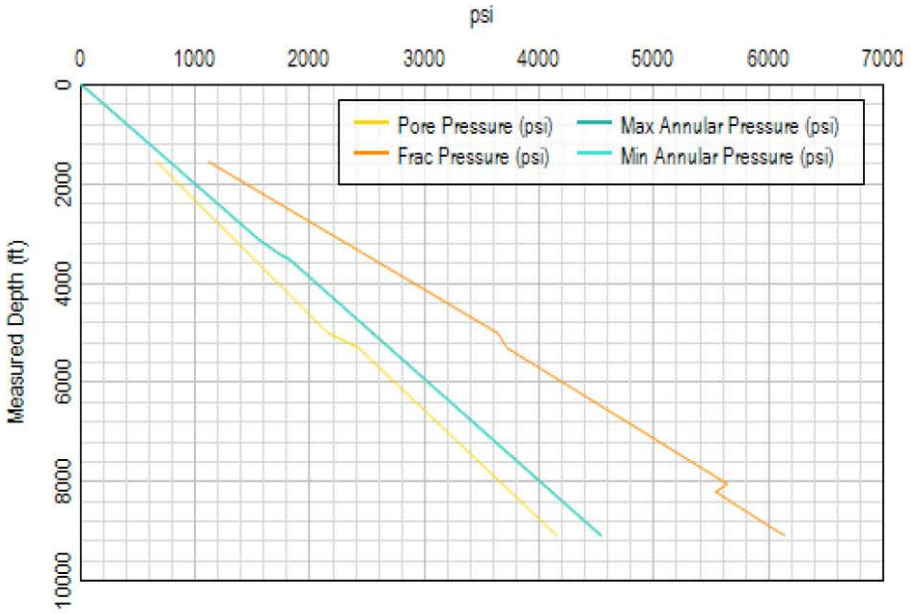
| | | | |
|---|---|---|---|
| Circulating Fluid: | OBM | Total Volume: | 182.0 bbl |
| Circulation Direction: | Direct | Number of Circulations: | 0.818 |

## Circulation Stages

| Stage | Pump Rate bbl/min | Duration hr:mn | Volume bbl | Back-pressure psi |
|---|---|---|---|---|
| OBM | 8.0 | 00:23 | 182.0 | 0 |

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 335 | 1551.5 | 00:21 |
| Success | Production/Influx | 108 | 1551.5 | 00:23 |
| Success | Burst | 9393 | 0.0 | 00:21 |
| Success | Collapse | 9778 | 3119.0 | 00:00 |

## Post-Placement Well Control






# Cypress M2
# Shannon Plug
version 5 plug 4
1/22/2024

Rig : True Drilling 38

Prepared for:
**Ricardo Mendez**
Tallgrass Energy
7202996780
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Prepared by:
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720 369 8051
jvaladez2@slb.com

# Job Objectives and Design Considerations

## Job Objectives

Mud company to spot 500' viscous pill below 5386' prior cement operations to support plug.
Circ. to cool down well and condition mud as per schedule.
Cement balanced plug to abandon Shannon formation (5286-6697') from 5386-5186' (100' above Shannon and 100' below, 200' plug length) in 8 3/4" OH (5% over caliper), no plan of tagging (expected TOC ~5213'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (4886') @ 40'/min rotating pipe slow and circulate to clean out excess.

## Acceptance Criteria

Pump plug as per design

### Operational Risk Statement

Cement plugs operations are complex to design and execute and this complexity should not be underestimated. Cement plugs operations should never be considered as a "routine" job. To successfully set cement plugs the same methodology used to design and execute primary cement jobs is required, which includes but is not limited to correct slurry design, mud-removal and placement design based on accurate well data. Cement plugs are remedial cementing treatments. The first design step is the determination of the actual problem to solve, i.e. define the purpose of setting a cement plug. The second step consists in defining the evaluation criteria: tag / no tag, positive pressure test, negative test, etc. Both steps allow for the proper specification of slurry properties and the determination of the adequate plug placement technique. This can result in additional laboratory tests as well as additional equipment requirements.

Nelson in Well Cementing (2006) discusses several factors that are key to successful plug cementing operations.
Displacement and under-displacement volumes play a critical role for the success of the job. The volumes specified in this program should be followed.
Fluid contamination/mixing during plug setting can jeopardize job success. To mitigate this risk, using a stable base for the plug, mechanical separators, and appropriate wait-on-cement-time is strongly recommended.
In case of a Kick-off Plug, proper knowledge of the BHA and application of correct drilling techniques are required to kick-off.

In case of any deviation from the approved job procedure, a Management of Change (MoC) is required. By raising a MoC to the appropriate level within the operator organization as well as within SLB, all the operational risks can be identified and addressed prior to execution of the cement plug.

# Plug Operation Summary

Overview of the cementing operation (temperatures, fluid types, rates and general notes)
**All depths (except water depth) take the rig floor as reference**

## Well & Rig Information

| | |
|---|---|
| Rig Type: | Land |

Objective: Mud company to spot 500' viscous pill below 5386' prior cement operations to support plug.
Cement balanced plug to abandon Shannon formation (5286-6697') from 5386-5186' (100' above Shannon and 100' below, 200' plug length) in 8 3/4" OH (5% over caliper), no plan of tagging (expected TOC ~5213'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (4886') @ 40'/min rotating pipe slow and circulate to clean out excess.

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |
| Well Deviation: | 0.0 deg |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Placement & Post-Placement Conditions

| | |
|---|---|
| **Top:** | **5186 ft** |
| Length: | 200.0 ft |
| **Bottom:** | **5386.0 ft** |
| **Support:** | **VISCOUS PILL** |

| | |
|---|---|
| Mechanical Separator: | AHEAD AND BEHIND |
| Pipe Rotation / Reciprocation: | ROTATION |

| | |
|---|---|
| POOH Depth: | 4886.0 ft |
| POOH Speed: | 30-40FT/MIN |
| Circ. Rate: | 8.0 bbl/min |
| Circ. Direction: | Direct |

| | |
|---|---|
| String type and configuration: | OPEN ENDED |

## Design Considerations

| G P4 | |
|---|---|
| Cement Type: | Slurry |
| Slurry Dens.: | 15.80 lb/gal |

| MUDPUSH Express | |
|---|---|
| Spacer Type: | Spacer |
| Spacer Dens.: | 12.00 lb/gal |

| OBM | |
|---|---|
| Mud Type: | Oil Based Mud |
| Mud Dens.: | 9.40 lb/gal |

| | | | |
|---|---|---|---|
| **Volume Balance Model:** | Optimize Slurry & Spacer | Underdispl.: | 0.0 bbl |

## Pumping Schedule

| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Comment | Inj. Temp. degF |
|---|---|---|---|---|---|
| Pause | | | 00:00 | Circ to cool down well and cond mud 60min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.8 | 5.0 | 00:04 | | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| G P4 | 15.5 | 5.0 | 00:03 | MinTT 3:27 | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| MUDPUSH Express | 6.2 | 5.0 | 00:01 | | 80.0 |
| OBM | 85.5 | 5.0 | 00:17 | | 80.0 |
| Pause | | | 00:10 | Break cmt. lines | |
| Pause | | | 00:13 | POOH 300' above TOC @40'/min, rotate pipe | |

| | | | | | |
|---|---|---|---|---|---|
| Pause | | | 00:33 | Rig circ. pipe clean excess 260bbl @ 8bpm | |
| Pause | | | 00:00 | | |
| Shut-in | | | 00:00 | | |

| Temperature Simulation | | | | |
|---|---|---|---|---|
| Pre-job Circ. Rate: | 8 bbl/min | | BHST: | 157.3 degF |
| Pre-job Circ. Time: | 60 MIN | | Simulated BHCT: | 116.3 degF |

# Well Data Summary

The cementing program incorporates the following data:
**All depths (except water depth) take the rig floor as reference**

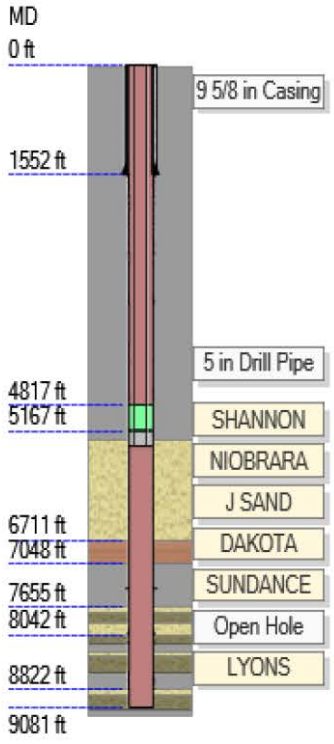
| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Tubulars and Casing Hardware

| | MD ft | OD in | Weight lb/ft | Grade | ID in | Thread | Collapse psi | Burst psi | Joint ft |
|---|---|---|---|---|---|---|---|---|---|
| Prev Casing | 1551.5 | 9 5/8 | 40.0 | J-55 | 8.835 | | 2570 | 3950 | 1.0 |
| Workstring | 5386.0 | 5 | 19.5 | E75 | 4.276 | | 10000 | 9500 | 40.0 |

Note: previous casing (and riser) collapse and burst security not verified



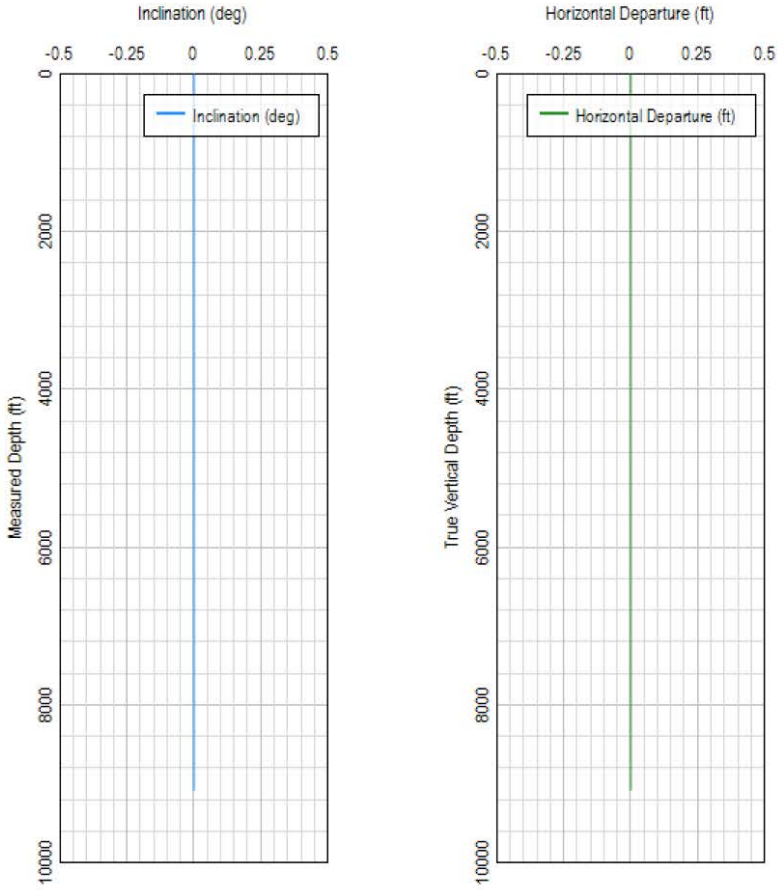

## Open Hole

| | |
|---|---|
| Total OH Volume: | 588.0 bbl |
| Minimum Diameter: | 8.473 in |
| Maximum Diameter: | 12.776 in |

| | |
|---|---|
| Mean Diameter: | 8.750 in |
| Mean Ann. Excess: | 0.000 % |
| Mean Eq. Diameter: | 8.966 in |

Note : OH caliper was uploaded.

## Directional Survey



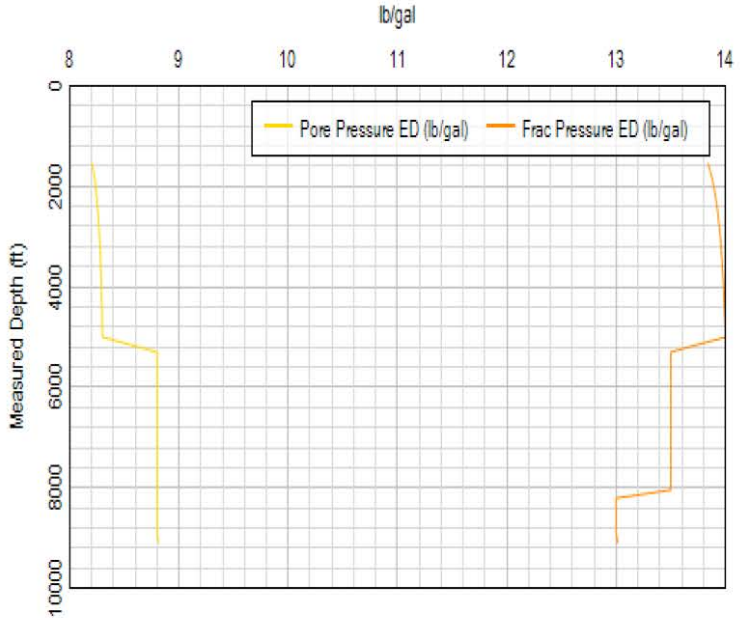

**Note:** Hole assumed vertical

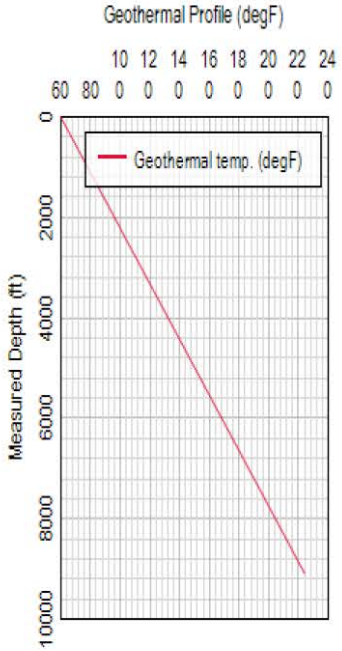
## Formation

| Top MD ft | Bottom MD ft | Bottom TVD ft | Frac Top ED lb/gal | Frac Bottom ED lb/gal | Pore Top ED lb/gal | Pore Bottom ED lb/gal | Lithology | Res. Fluid | Name |
|---|---|---|---|---|---|---|---|---|---|
| 25.5 | 5000.0 | 5000.0 | 0.00 | 14.00 | 0.00 | 8.30 | | | |
| 5000.0 | 5299.0 | 5299.0 | 14.00 | 13.50 | 8.30 | 8.80 | | | |
| 5299.0 | 6711.0 | 6711.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | SHANNON |
| 6711.0 | 7048.0 | 7048.0 | 13.50 | 13.50 | 8.80 | 8.80 | Shale | | NIOBRARA |
| 7048.0 | 7250.0 | 7250.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7250.0 | 7655.0 | 7655.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7655.0 | 7734.0 | 7734.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | J SAND |
| 7734.0 | 7894.0 | 7894.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7894.0 | 8042.0 | 8042.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | DAKOTA |
| 8042.0 | 8200.0 | 8200.0 | 13.50 | 13.00 | 8.80 | 8.80 | | | |
| 8200.0 | 8274.0 | 8274.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8274.0 | 8336.0 | 8336.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | SUNDANCE |
| 8336.0 | 8500.0 | 8500.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8500.0 | 8600.0 | 8600.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8600.0 | 8682.0 | 8682.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8682.0 | 8822.0 | 8822.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8822.0 | 8891.0 | 8891.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | LYONS |
| 8891.0 | 9081.0 | 9081.0 | 13.00 | 13.01 | 8.80 | 8.81 | | | |

| Temperature | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Top MD ft | Bottom MD ft | Bottom TVD ft | Temp. degF | Temp. Gradient degF/100ft | Temp. Rel. Gradient degF/100ft | |
| Surface | 0.0 | 0.0 | 0.0 | 60.0 | 0.00 | | |
| BHST | 0.0 | 5386.0 | 5386.0 | 157.3 | 1.81 | 1.81 | |
| Rock | 5386.0 | 9081.0 | 9081.0 | 224.0 | 1.81 | 1.81 | |

**Source of temperature data:** 224degF at BH from 3 different SLB WL Logs, confirmed with client

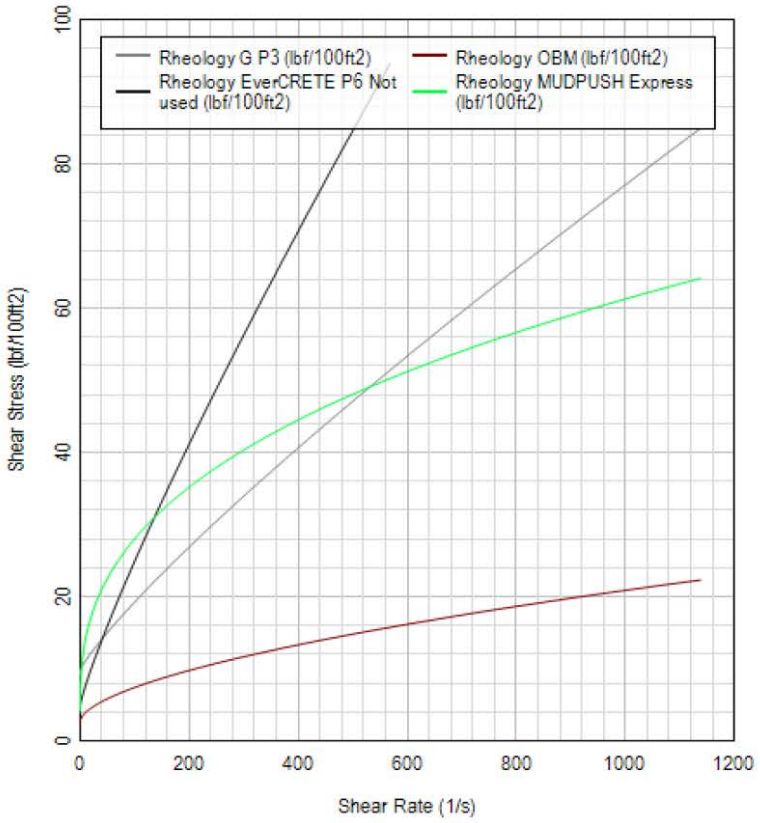


# Fluids Summary

| Fluids | | | | | | |
|---|---|---|---|---|---|---|
| Type | Name | Density lb/gal | Conditions | K lbf.s^n/ft2 | n | Ty lbf/100ft2 |
| Drilling Fluid | OBM | 9.40 | Downhole 190.0 degF | 3.03E-3 | 0.589 | 2.59 |
| Spacer | MUDPUSH Express | 12.00 | Downhole 190.0 degF WND 2023-153 | 3.94E-2 | 0.381 | 4.10 |
| Slurry | G P4 | 15.80 | Downhole 171.0 degF CWY 2022-301 | 1.86E-3 | 0.852 | 9.20 |

* Rheology and density of compressible fluids are displayed at standard conditions, ie. P = 1 atm and T = 20 degC (65 degF)




| Fluid Density and Rheology Tolerance |
|---|
| **Mud** – properties to be verified prior to job with mud engineer, contact engineer onshore if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg rheology difference from planned : +/- 10% |
| **Spacer** – properties to be verified prior to job, see contingency plans if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg |
| **Slurry** – cement slurry should be mixed within the range described below, see contingency plans if there is mismatch between designed density and slurry volume<br>density difference from planned : +/- 0.2 ppg |

# Mud Circulation

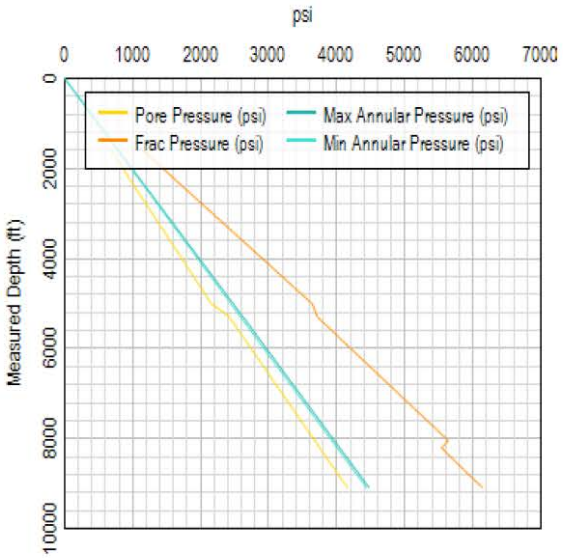
| | |
|---|---|
| Fluid | OBM |
| Number of Circulations | 1.248 |
| Total Volume at Ambient Temperature | 480.0 bbl |
| Ambient Temperature | 80.0 degF |
| Correction Slope | 0.700 |

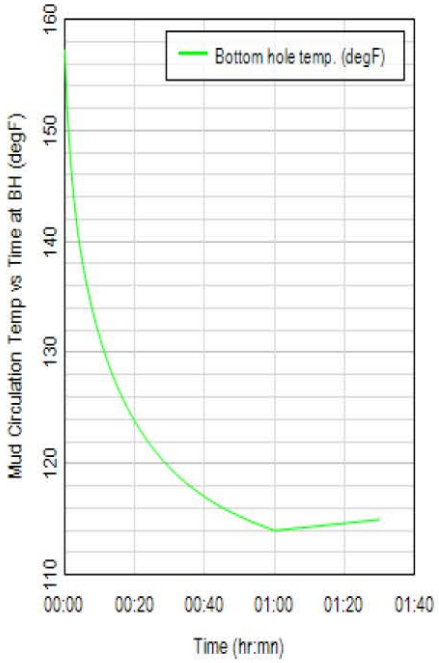
**Pumping Stages**

| Fluid | Pump Rate bbl/min | Duration hr:mn | Volume bbl |
|---|---|---|---|
| OBM | 8.0 | 01:00 | 480.0 |
| Pause | | 00:30 | |

**Well Security**

| Status | Description | Min Differential Pressure psi | At Depth ft | At Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 346 | 1551.5 | 01:00 |
| Success | Production/Influx | 96 | 1551.5 | 01:30 |
| Success | Burst | 9335 | 0.0 | 00:00 |
| Success | Collapse | 9619 | 5386.0 | 01:30 |



# Fluid Placement

## Volume Balance Objectives

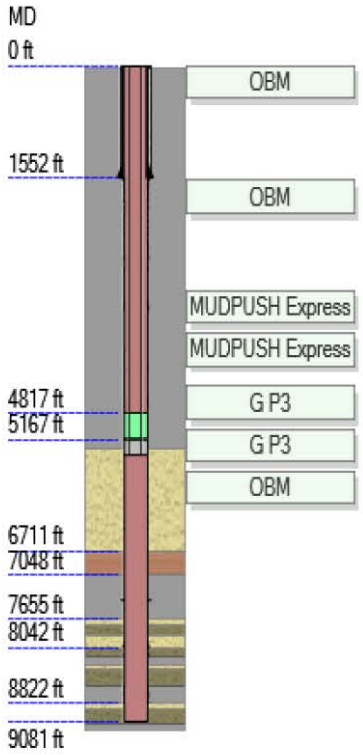
Volume Balance Model: **Optimize Slurry & Spacer**

| | | | | | |
|---|---|---|---|---|---|
| Original Fluid: | OBM | Rat Hole Fluid: | OBM | Displ. Fluid: | OBM |
| Top Spacer: | MUDPUSH Express | set Total Volume to: | 25.0 bbl | | |
| Top Slurry: | G P4 | set Top MD to: | 5186.0 ft | | |

Annulus is **not** filled during POOH.

## Volume Balance Results

| | | | | | |
|---|---|---|---|---|---|
| String Volume: | 95.7 bbl | Underdispl.: | 0.0 bbl | Displ. Volume: | 85.5 bbl |
| TOC after POOH: | 5186.0 ft | Cement Length after POOH: | 200.0 ft | | |




## Fluid Placement in Annulus

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.0 | 4817.6 | 4817.6 | 258.6 | 9.40 |
| MUDPUSH Express | 4817.6 | 5167.8 | 350.3 | 18.8 | 12.00 |
| G P4 | 5167.8 | 5386.0 | 218.2 | 11.7 | 15.80 |

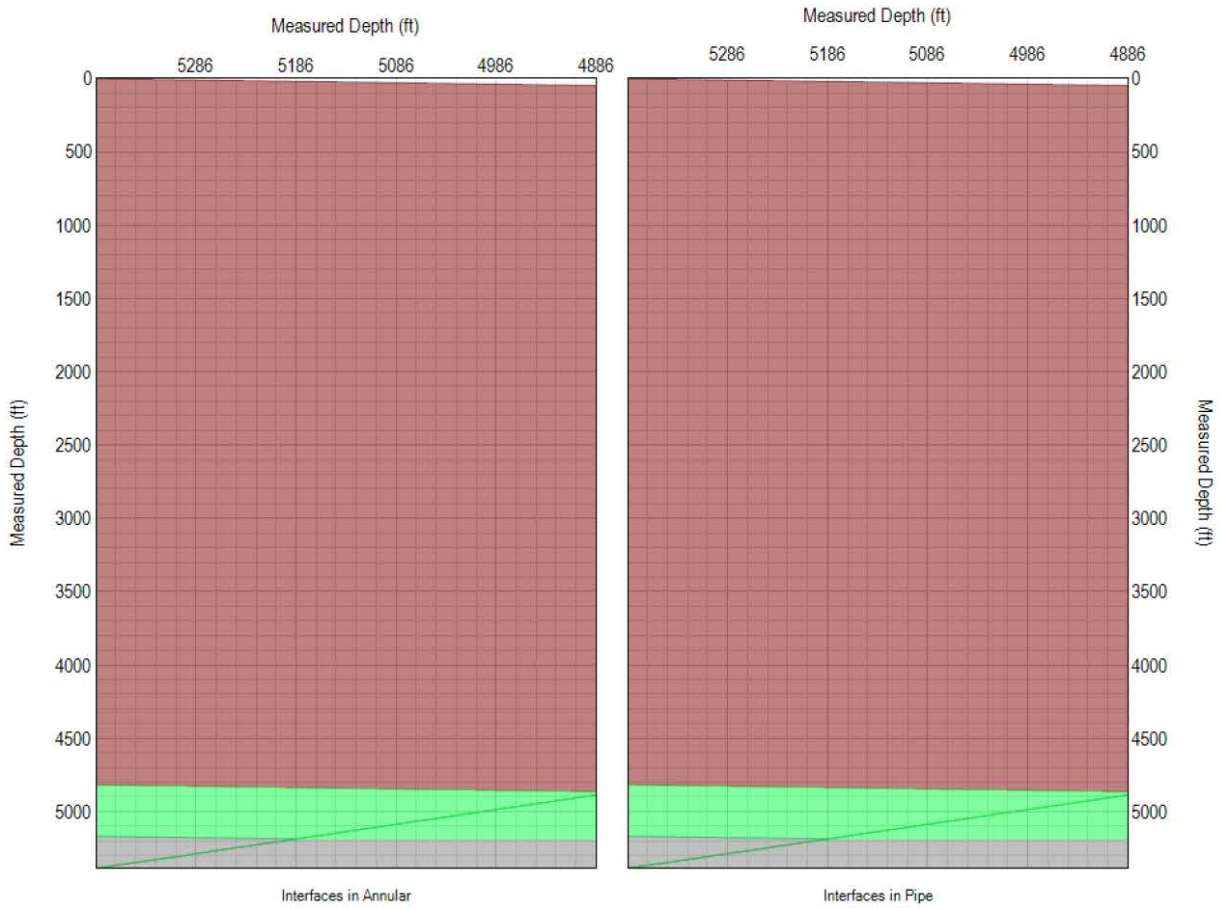
## Fluid Placement in Pipe

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.5 | 4816.6 | 4816.2 | 85.5 | 9.40 |
| MUDPUSH Express | 4816.6 | 5167.4 | 350.7 | 6.2 | 12.00 |
| G P4 | 5167.4 | 5386.0 | 218.6 | 3.9 | 15.80 |

# Static Pull Out Of Hole (POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP Depth: | 4886.0 ft | | Theoretical Top of Plug: | 5186.0 ft |
| POOH Length: | 500.0 ft | | Theoretical Plug Length: | 200.0 ft |
| POOH Speed: | 30-40ft/min | | Plug Bottom: | 5386.0 ft |
| **Top of uncontaminated cement after POOH:** | | | | **5186.0 ft** |
| **Uncontaminated cement length after POOH:** | | | | **5186.0 ft** |
| Contaminated cement length after POOH: | | | | 0.0 ft |

## POOH Results Summary




Note: Simulation assumes that fluids are free to balance themselves.

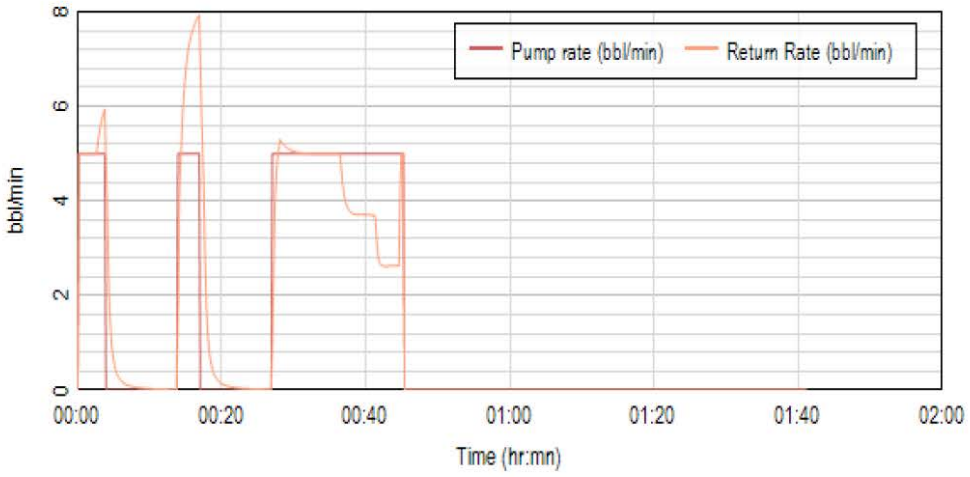
# Pumping Schedule

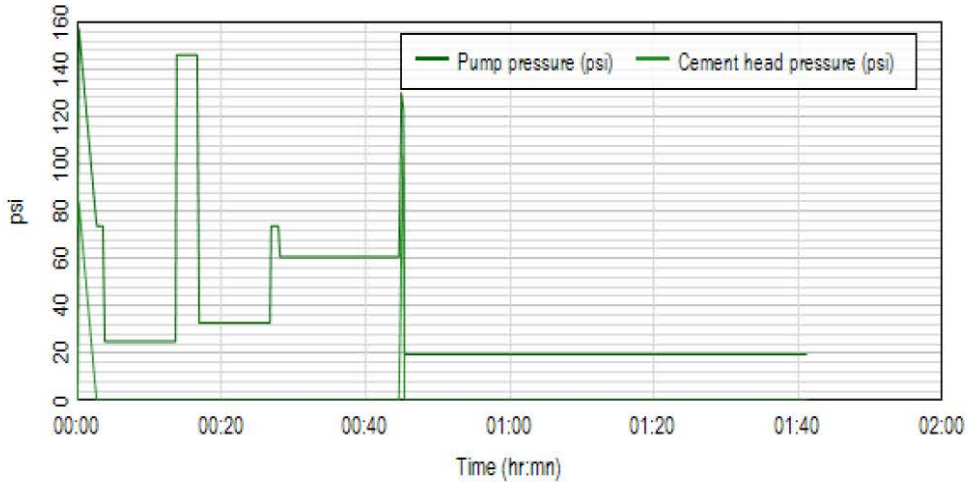
| Pumping Schedule | | | | | | |
|---|---|---|---|---|---|---|
| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Cum. Time hr:mn | Comment | Inj. Temp. degF |
| Pause | | | 00:00 | 00:00 | Circ to cool down well and cond mud 60min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.8 | 5.0 | 00:04 | 00:04 | | 80.0 |
| Plug | | | 00:10 | 00:14 | Foam ball | |
| G P4 | 15.5 | 5.0 | 00:03 | 00:17 | MinTT 3:27 | 80.0 |
| Plug | | | 00:10 | 00:27 | Foam ball | |
| MUDPUSH Express | 6.2 | 5.0 | 00:01 | 00:28 | | 80.0 |
| OBM | 85.5 | 5.0 | 00:17 | 00:45 | | 80.0 |
| Pause | | | 00:10 | 00:55 | Break cmt. lines | |
| Pause | | | 00:13 | 01:08 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:33 | 01:41 | Rig circ. pipe clean excess 260bbl @ 8bpm | |
| Pause | | | 00:00 | 01:41 | | |
| Shut-in | | | 00:00 | 01:41 | | |

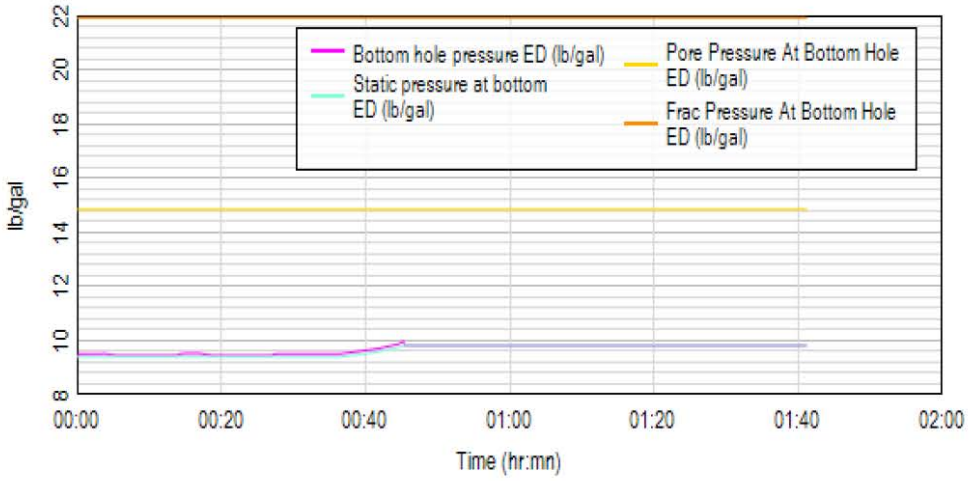
| | |
|---|---|
| Maximum Required Hydraulic Horsepower (HHP) | 19.3 hhp (at 00:00 hr:mn) |

| Displacement Volume Considerations | | |
|---|---|---|
| | Volume bbl | Variation bbl |
| Theoretical displacement volume | 85.6 | |
| Underdisplacement | | 0.0 |
| Final Displacement | 85.5 | |

Pauses in the jobs are only estimates – all efforts should be made during the operation to minimize these times.



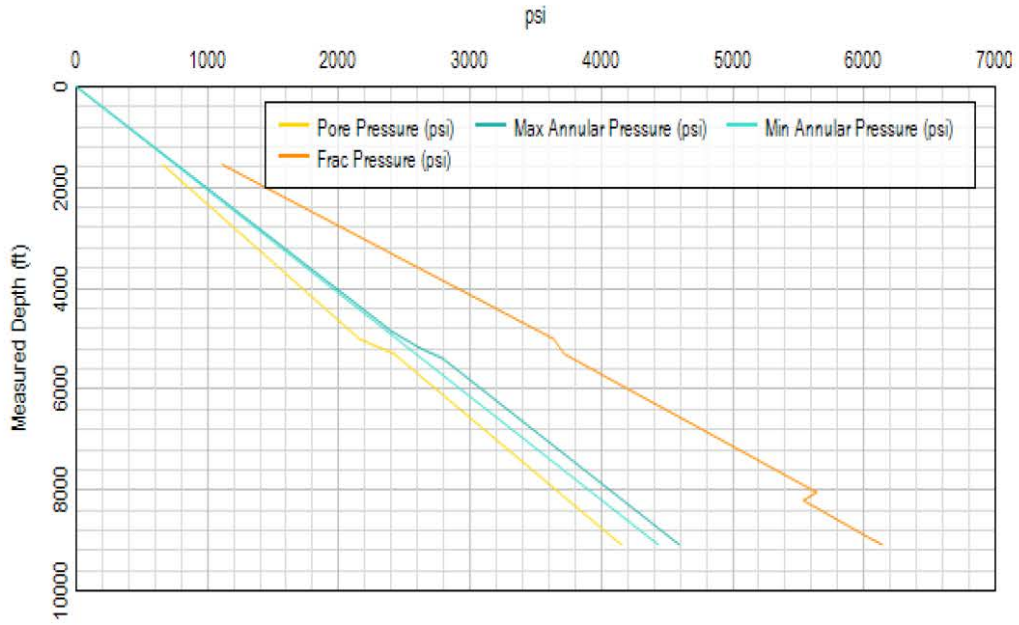

Pump pressure (psi)
Cement head pressure (psi)
psi
0
20
40
60
80
100
120
140
160
00:00
00:20
00:40
01:00
01:20
01:40
02:00
Time (hr:mn)


Bottom hole pressure ED (lb/gal)
Static pressure at bottom ED (lb/gal)
Pore Pressure At Bottom Hole ED (lb/gal)
Frac Pressure At Bottom Hole ED (lb/gal)
lb/gal
8
10
12
14
16
18
20
22
00:00
00:20
00:40
01:00
01:20
01:40
02:00
Time (hr:mn)

# Well Security

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 346 | 1551.5 | 00:17 |
| Success | Production/Influx | 96 | 1551.5 | 01:41 |
| Success | Burst | 9397 | 0.0 | 00:45 |
| Success | Collapse | 9370 | 3100.4 | 00:36 |

## Well Control



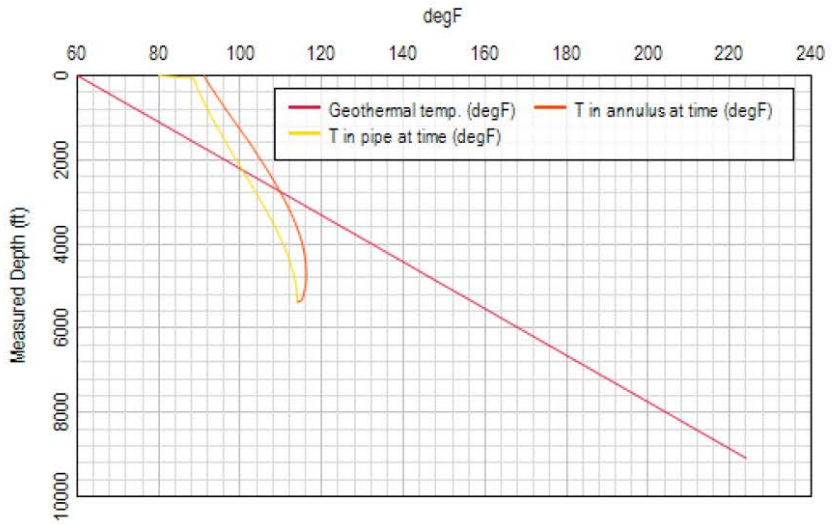
# Temperature Outputs

| | |
|---|---|
| BHST: | 157.3 degF |
| Static Temp at TOC: | 153.3 degF |

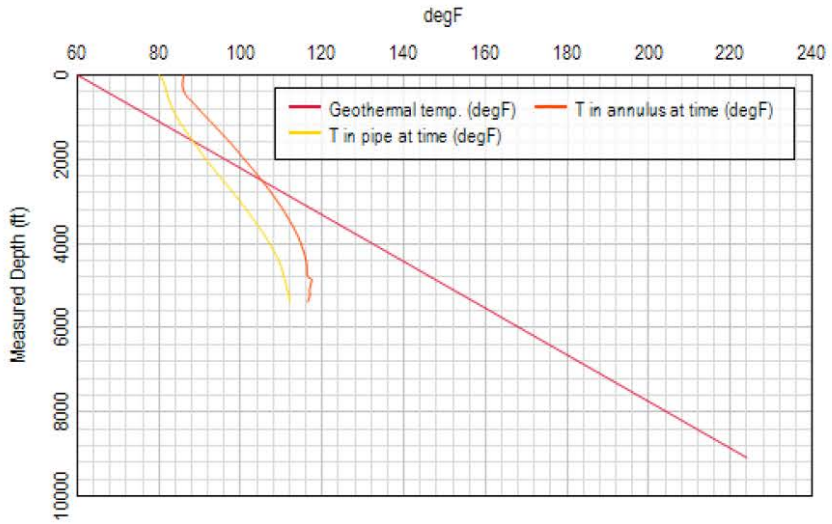
| | |
|---|---|
| Simulated BHCT: | 116.3 degF |
| Simulated HCT at TOC: | 116.9 degF |

Temperature simulation initial condition: Mud Circulation profile

## Initial Condition

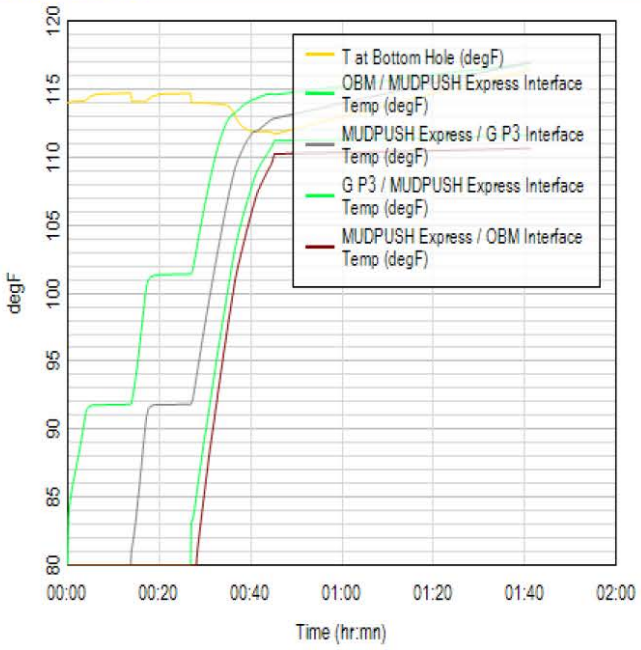



## Final Condition

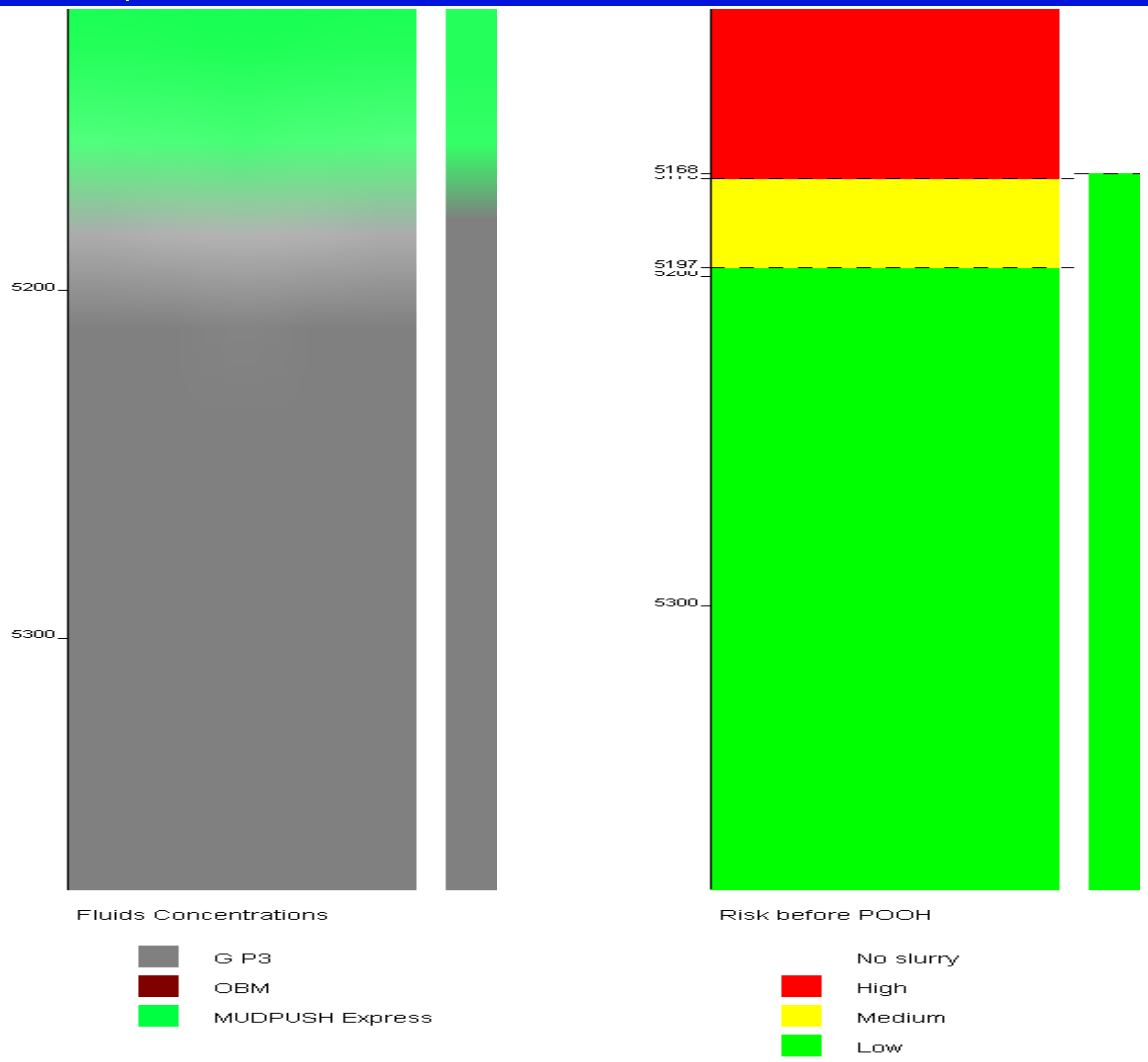



t = 01:41 hr:mn

## BHCT and Interface Temperatures



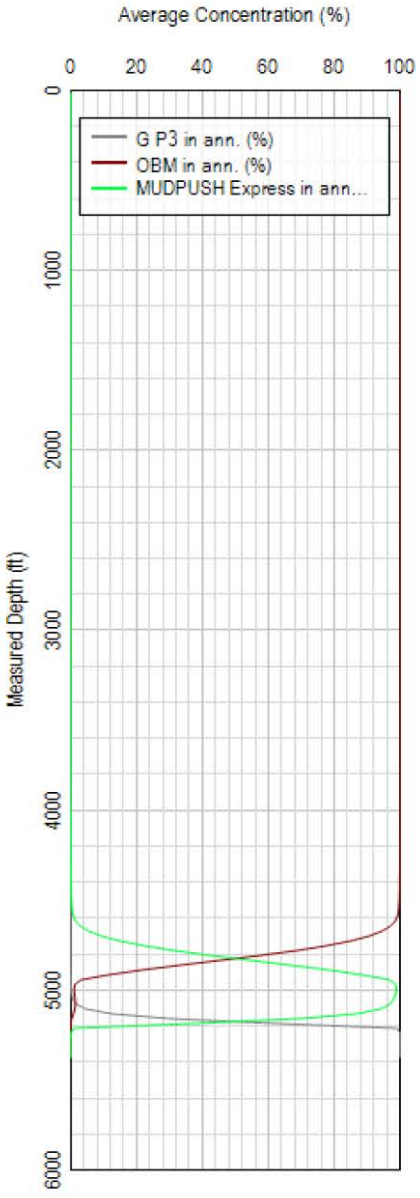
## WELLCLEAN III Maps



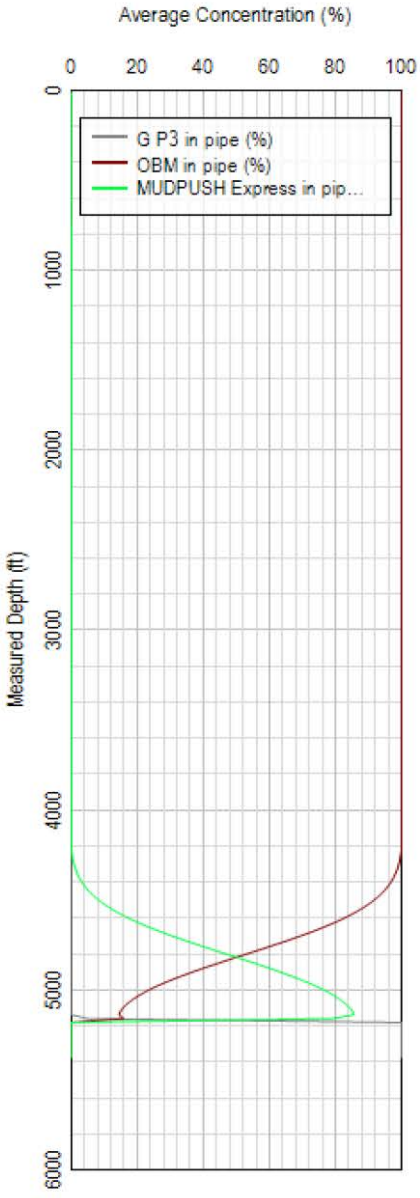

| | |
|---|---|
| **No cement slurry** | Slurry concentration is less than 10% (by unit of volume).<br>The concentration is below minimum threshold to consider that cement is present. |
| **High risk of contamination** | Slurry concentration is between 10% and 50% (by unit of volume).<br>There is no chance of finding hard cement when tagging within a few hours. |
| **Medium risk of contamination** | Slurry concentration is between 50% and 90% (by unit of volume).<br>It is possible to find some soft cement when tagging but it will most likely not be strong enough to kick off the well or even to provide a proper wellbore isolation. |
| **Low risk of contamination** | Slurry concentration is between 90% and 100% (by unit of volume).<br>Cement plug should be designed in such a way that the target of the top of cement should be within the 'green risk' zone. Hard cement should be found in that zone once compressive strength has developed, i.e. after the duration determined by the lab tests at downhole condition. |

## Fluid Concentrations before POOH

Average fluid concentration in annulus



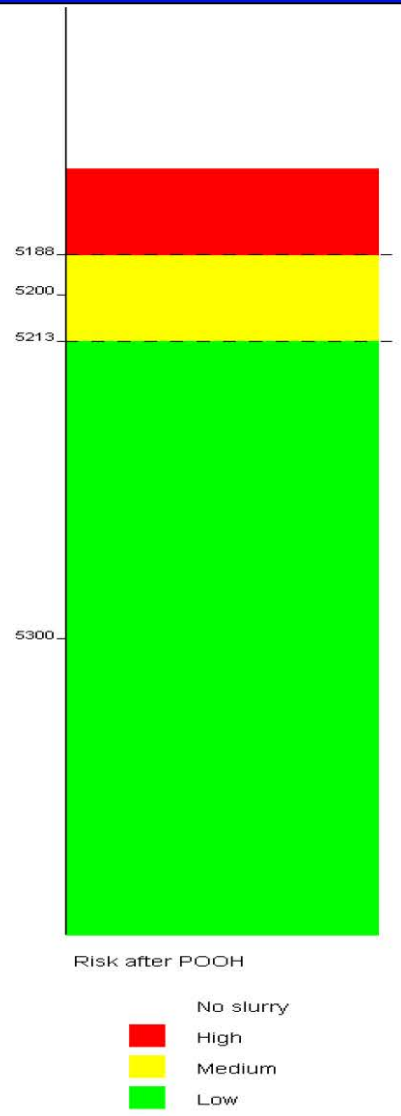

Average fluid concentration in pipe



# Final Contamination Risk (After POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP depth: | 4886.0 ft | | Theoretical Top of Plug: | 5186.0 ft |
| Theoretical Top of Plug (based on slurry volume) | | | | 5186.0 ft |
| Estimated TOC based on uncontaminated POOH simulation | | | | 0.0 ft |
| Estimated TOC after POOH considering contamination during placement | | | | 5213.5 ft |

## Final Contamination Risk




Note: Simulation assumes that fluids are free to balance themselves

# Post-placement Circulation

Volume of compressible fluids is displayed at ambient conditions, ie. P = 1 atm and T = 60.0 degF

| | | | |
|---|---|---|---|
| DP Depth for Circulation: | 4886.0 ft | Designed TOC: | 5186.0 ft |

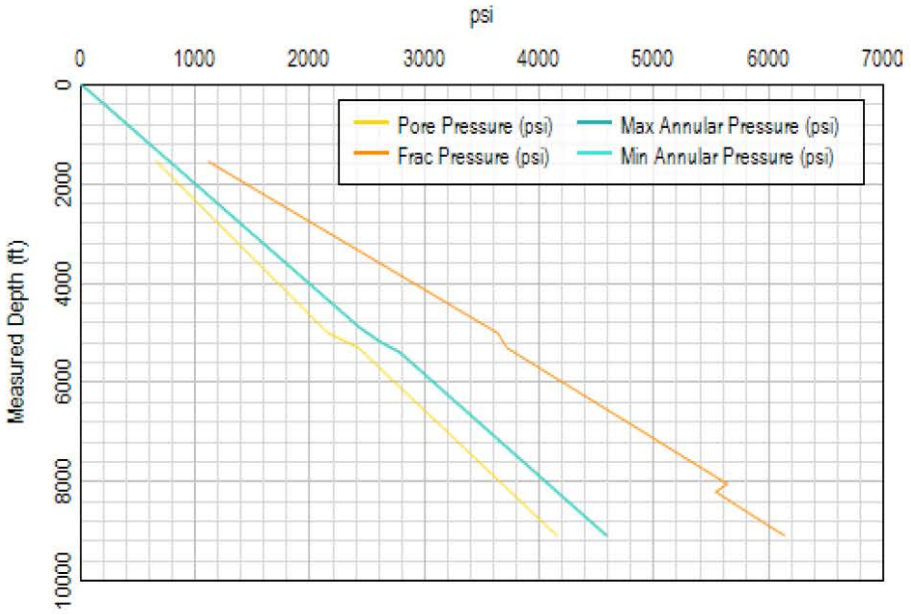
| | | | |
|---|---|---|---|
| Circulating Fluid: | OBM | Total Volume: | 264.0 bbl |
| Circulation Direction: | Direct | Number of Circulations: | 0.756 |

## Circulation Stages

| Stage | Pump Rate bbl/min | Duration hr:mn | Volume bbl | Back-pressure psi |
|---|---|---|---|---|
| OBM | 8.0 | 00:33 | 264.0 | 0 |

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 332 | 1551.5 | 00:32 |
| Success | Production/Influx | 108 | 1551.5 | 00:33 |
| Success | Burst | 9336 | 0.0 | 00:32 |
| Success | Collapse | 9653 | 4886.0 | 00:00 |

## Post-Placement Well Control






# Cypress M2
# Niobrara Plug
## version 5 plug 5
## 1/22/2024

Rig : True Drilling 38

Prepared for:
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# Job Objectives and Design Considerations

## Job Objectives

Mud company to spot 200' viscous pill below 6748' prior cement operations to support plug.
Circ. to cool down well and condition mud as per schedule.
Cement balanced plug to abandon Niobrara formation (6697-7034') from 6748-6648' (49' above Niobrara and 51' below, 100' plug length) in 8 3/4" OH (5% excess over caliper), no plan of tagging (expected TOC ~6686'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (6348') @ 40'/min rotating pipe slow and circulate to clean out excess.

## Acceptance Criteria

Pump cement plug as per design

### Operational Risk Statement

Cement plugs operations are complex to design and execute and this complexity should not be underestimated. Cement plugs operations should never be considered as a "routine" job. To successfully set cement plugs the same methodology used to design and execute primary cement jobs is required, which includes but is not limited to correct slurry design, mud-removal and placement design based on accurate well data. Cement plugs are remedial cementing treatments. The first design step is the determination of the actual problem to solve, i.e. define the purpose of setting a cement plug. The second step consists in defining the evaluation criteria: tag / no tag, positive pressure test, negative test, etc. Both steps allow for the proper specification of slurry properties and the determination of the adequate plug placement technique. This can result in additional laboratory tests as well as additional equipment requirements.

Nelson in Well Cementing (2006) discusses several factors that are key to successful plug cementing operations.
Displacement and under-displacement volumes play a critical role for the success of the job. The volumes specified in this program should be followed.
Fluid contamination/mixing during plug setting can jeopardize job success. To mitigate this risk, using a stable base for the plug, mechanical separators, and appropriate wait-on-cement-time is strongly recommended.
In case of a Kick-off Plug, proper knowledge of the BHA and application of correct drilling techniques are required to kick-off.

In case of any deviation from the approved job procedure, a Management of Change (MoC) is required. By raising a MoC to the appropriate level within the operator organization as well as within SLB, all the operational risks can be identified and addressed prior to execution of the cement plug.

# Plug Operation Summary

Overview of the cementing operation (temperatures, fluid types, rates and general notes)
**All depths (except water depth) take the rig floor as reference**

## Well & Rig Information

| | |
|---|---|
| Rig Type: | Land |

Objective: Mud company to spot 200' viscous pill below 6748' prior cement operations to support plug.
Circ. to cool down well and condition mud as per schedule.
Cement balanced plug to abandon Niobrara formation (6697-7034') from 6748-6648' (49' above Niobrara and 51' below, 100' plug length) in 8 3/4" OH (5% excess over caliper), no plan of tagging (expected TOC ~6686'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (6348') @ 40'/min rotating pipe slow and circulate to clean out excess.

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |
| Well Deviation: | 0.0 deg |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Placement & Post-Placement Conditions

| | |
|---|---|
| **Top:** | **6648.0 ft** |
| Length: | 100.0 ft |
| **Bottom:** | **6748.0 ft** |
| **Support:** | **VISCOUS PILL** |

| | |
|---|---|
| Mechanical Separator: | AHEAD AND BEHIND |
| Pipe Rotation / Reciprocation: | ROTATION |

| | |
|---|---|
| POOH Depth: | 6348.0 ft |
| POOH Speed: | 30-40FT/MIN |
| Circ. Rate: | 8.0 bbl/min |
| Circ. Direction: | Direct |

| | |
|---|---|
| String type and configuration: | OPEN ENDED |

## Design Considerations

| G P5 | |
|---|---|
| Cement Type: | Slurry |
| Slurry Dens.: | 15.80 lb/gal |

| MUDPUSH Express | |
|---|---|
| Spacer Type: | Spacer |
| Spacer Dens.: | 12.00 lb/gal |

| OBM | |
|---|---|
| Mud Type: | Oil Based Mud |
| Mud Dens.: | 9.40 lb/gal |

| | | | |
|---|---|---|---|
| **Volume Balance Model:** | Optimize Slurry & Spacer | Underdispl.: | 0.0 bbl |

## Pumping Schedule

| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Comment | Inj. Temp. degF |
|---|---|---|---|---|---|
| Pause | | | 00:00 | Circ to cool down well and cond mud 90min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.6 | 5.0 | 00:04 | | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| G P5 | 7.6 | 5.0 | 00:02 | MinTT 3:40 | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| MUDPUSH Express | 6.4 | 5.0 | 00:01 | | 80.0 |
| OBM | 111.6 | 5.0 | 00:22 | | 80.0 |



| | | | | | |
|---|---|---|---|---|---|
| Pause | | | 00:10 | Break cmt. lines | |
| Pause | | | 00:13 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:43 | Rig circ. pipe clean excess 350bbl @ 8bpm | |
| Pause | | | 00:00 | | |
| Shut-in | | | 00:00 | | |

| Temperature Simulation | | | | |
|---|---|---|---|---|
| Pre-job Circ. Rate: | 8 bbl/min | | BHST: | 181.9 degF |
| Pre-job Circ. Time: | 90MIN | | Simulated BHCT: | 135.6 degF |

# Well Data Summary

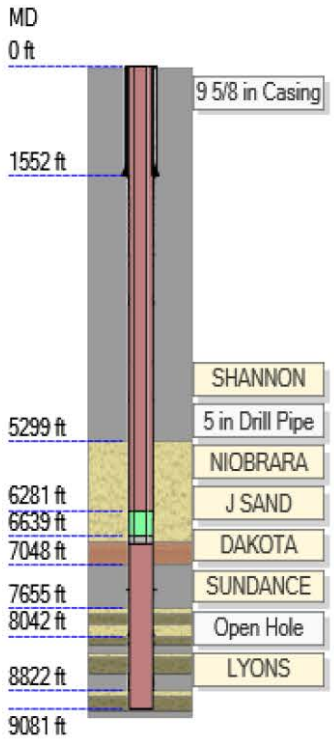
The cementing program incorporates the following data:
**All depths (except water depth) take the rig floor as reference**

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Tubulars and Casing Hardware

| | MD ft | OD in | Weight lb/ft | Grade | ID in | Thread | Collapse psi | Burst psi | Joint ft |
|---|---|---|---|---|---|---|---|---|---|
| Prev Casing | 1551.5 | 9 5/8 | 40.0 | J-55 | 8.835 | | 2570 | 3950 | 1.0 |
| Workstring | 6748.0 | 5 | 19.5 | E75 | 4.276 | | 10000 | 9500 | 40.0 |



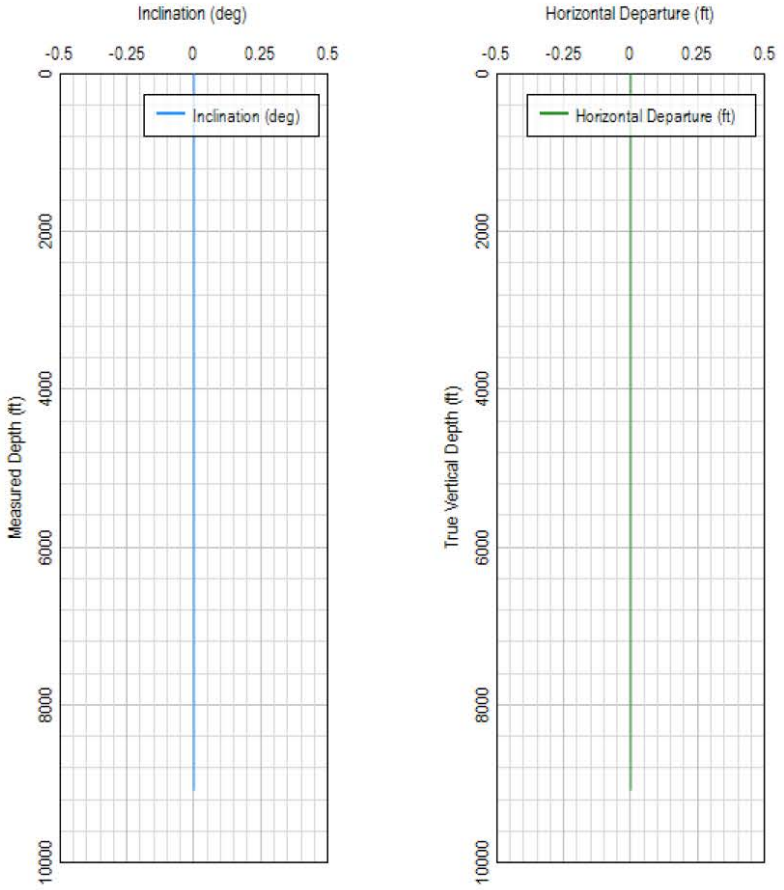

## Open Hole

| | |
|---|---|
| Total OH Volume: | 573.1 bbl |
| Minimum Diameter: | 8.473 in |
| Maximum Diameter: | 12.776 in |

| | |
|---|---|
| Mean Diameter: | 8.750 in |
| Mean Ann. Excess: | 5.000 % |
| Mean Eq. Diameter: | 8.852 in |

Note : OH caliper was uploaded.

## Directional Survey




**Note:** Hole assumed vertical

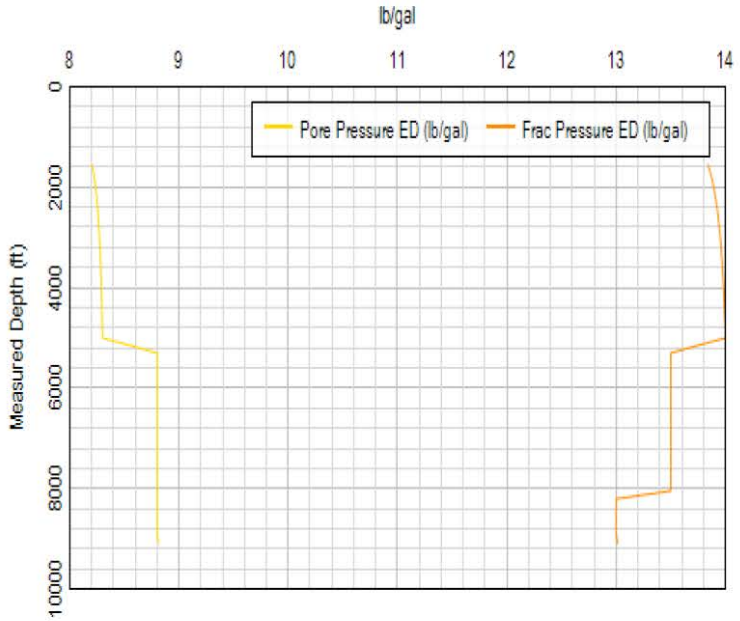
## Formation

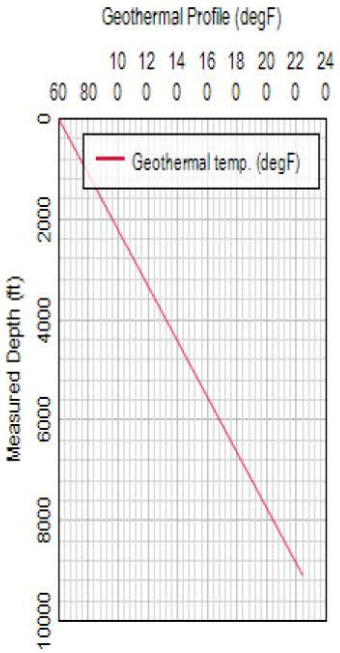
| Top MD ft | Bottom MD ft | Bottom TVD ft | Frac Top ED lb/gal | Frac Bottom ED lb/gal | Pore Top ED lb/gal | Pore Bottom ED lb/gal | Lithology | Res. Fluid | Name |
|---|---|---|---|---|---|---|---|---|---|
| 25.5 | 5000.0 | 5000.0 | 0.00 | 14.00 | 0.00 | 8.30 | | | |
| 5000.0 | 5299.0 | 5299.0 | 14.00 | 13.50 | 8.30 | 8.80 | | | |
| 5299.0 | 6711.0 | 6711.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | SHANNON |
| 6711.0 | 7048.0 | 7048.0 | 13.50 | 13.50 | 8.80 | 8.80 | Shale | | NIOBRARA |
| 7048.0 | 7250.0 | 7250.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7250.0 | 7655.0 | 7655.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7655.0 | 7734.0 | 7734.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | J SAND |
| 7734.0 | 7894.0 | 7894.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7894.0 | 8042.0 | 8042.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | DAKOTA |
| 8042.0 | 8200.0 | 8200.0 | 13.50 | 13.00 | 8.80 | 8.80 | | | |
| 8200.0 | 8274.0 | 8274.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8274.0 | 8336.0 | 8336.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | SUNDANCE |
| 8336.0 | 8500.0 | 8500.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8500.0 | 8600.0 | 8600.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8600.0 | 8682.0 | 8682.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8682.0 | 8822.0 | 8822.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8822.0 | 8891.0 | 8891.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | LYONS |
| 8891.0 | 9081.0 | 9081.0 | 13.00 | 13.01 | 8.80 | 8.81 | | | |

## Temperature

| Name | Top MD ft | Bottom MD ft | Bottom TVD ft | Temp. degF | Temp. Gradient degF/100ft | Temp. Rel. Gradient degF/100ft | |
|---|---|---|---|---|---|---|---|
| Surface | 0.0 | 0.0 | 0.0 | 60.0 | 0.00 | | |
| BHST | 0.0 | 6748.0 | 6748.0 | 161.9 | 1.81 | 1.81 | |
| Rock | 6748.0 | 6798.0 | 6798.0 | 162.8 | 1.81 | 1.81 | |
| Rock | 6798.0 | 9081.0 | 9081.0 | 224.0 | 1.81 | 1.81 | |

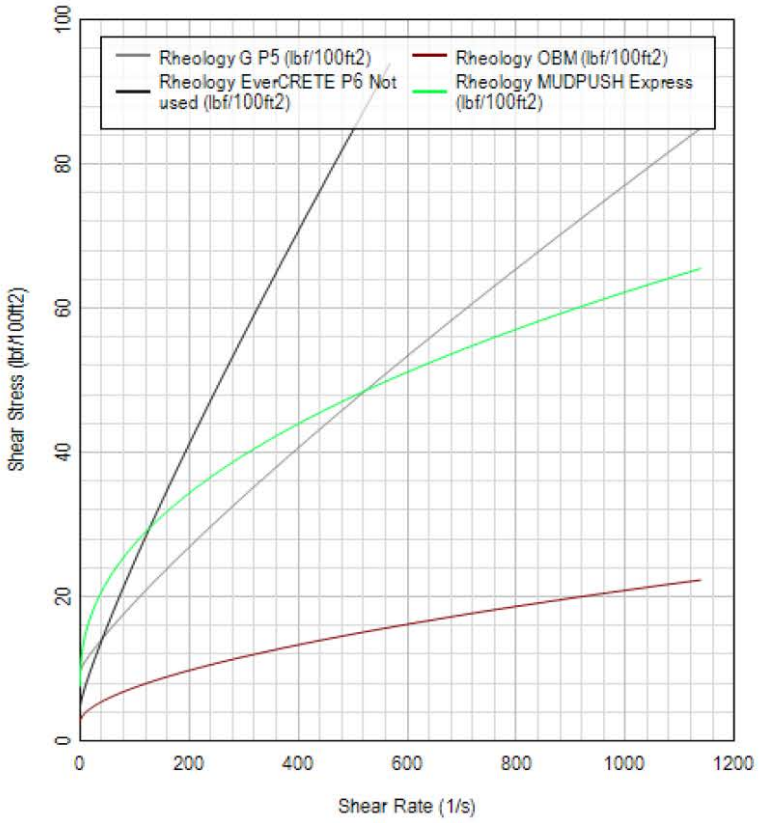
**Source of temperature data:** 224degF at BH from 3 different SLB WL Logs, confirmed with client



# Fluids Summary

| Fluids | | | | | | |
|---|---|---|---|---|---|---|
| Type | Name | Density lb/gal | Conditions | K lbf.s^n/ft2 | n | Ty lbf/100ft2 |
| Drilling Fluid | OBM | 9.40 | Downhole 190.0 degF | 3.03E-3 | 0.589 | 2.59 |
| Spacer | MUDPUSH Express | 12.00 | Downhole 190.0 degF WND 2023-153 | 2.36E-2 | 0.449 | 7.58 |
| Slurry | G P5 | 15.80 | Downhole 171.0 degF CWY 2022-301 | 1.86E-3 | 0.852 | 9.20 |




| Fluid Density and Rheology Tolerance |
|---|
| **Mud** – properties to be verified prior to job with mud engineer, contact engineer onshore if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg rheology difference from planned : +/- 10% |
| **Spacer** – properties to be verified prior to job, see contingency plans if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg |
| **Slurry** – cement slurry should be mixed within the range described below, see contingency plans if there is mismatch between designed density and slurry volume<br>density difference from planned : +/- 0.2 ppg |

# Mud Circulation

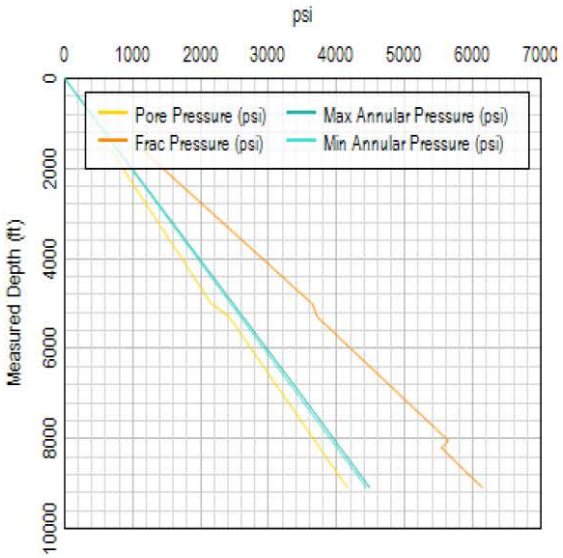
| | |
|---|---|
| Fluid | OBM |
| Number of Circulations | 1.516 |
| Total Volume at Ambient Temperature | 720.0 bbl |
| Ambient Temperature | 80.0 degF |
| Correction Slope | 0.700 |

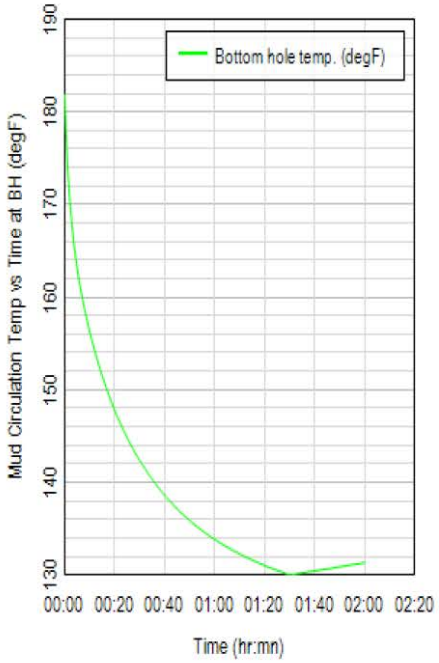
**Pumping Stages**

| Fluid | Pump Rate bbl/min | Duration hr:mn | Volume bbl |
|---|---|---|---|
| OBM | 8.0 | 01:30 | 720.0 |
| Pause | | 00:30 | |

**Well Security**

| Status | Description | Min Differential Pressure psi | At Depth ft | At Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 346 | 1551.5 | 01:30 |
| Success | Production/Influx | 96 | 1551.5 | 02:00 |
| Success | Burst | 9292 | 0.0 | 00:00 |
| Success | Collapse | 9523 | 6748.0 | 02:00 |



# Fluid Placement

## Volume Balance Objectives

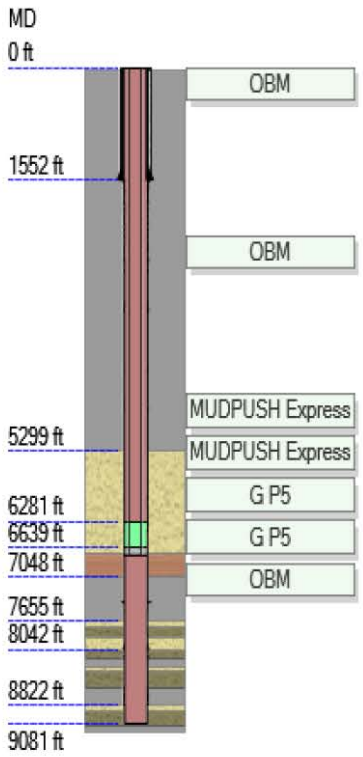
Volume Balance Model: **Optimize Slurry & Spacer**

| | | | | | |
|---|---|---|---|---|---|
| Original Fluid: | OBM | Rat Hole Fluid: | OBM | Displ. Fluid: | OBM |
| Top Spacer: | MUDPUSH Express | set Total Volume to: | 25.0 bbl | | |
| Top Slurry: | G P5 | set Top MD to: | 6648.0 ft | | |

Annulus is **not** filled during POOH.

## Volume Balance Results

| | | | | | |
|---|---|---|---|---|---|
| String Volume: | 119.9 bbl | Underdispl.: | 0.0 bbl | Displ. Volume: | 111.6 bbl |
| TOC after POOH: | 6648.0 ft | Cement Length after POOH: | 100.0 ft | | |




## Fluid Placement in Annulus

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.0 | 6281.4 | 6281.4 | 330.8 | 9.40 |
| MUDPUSH Express | 6281.4 | 6638.7 | 357.3 | 18.6 | 12.00 |
| G P5 | 6638.7 | 6748.0 | 109.3 | 5.7 | 15.80 |

## Fluid Placement in Pipe

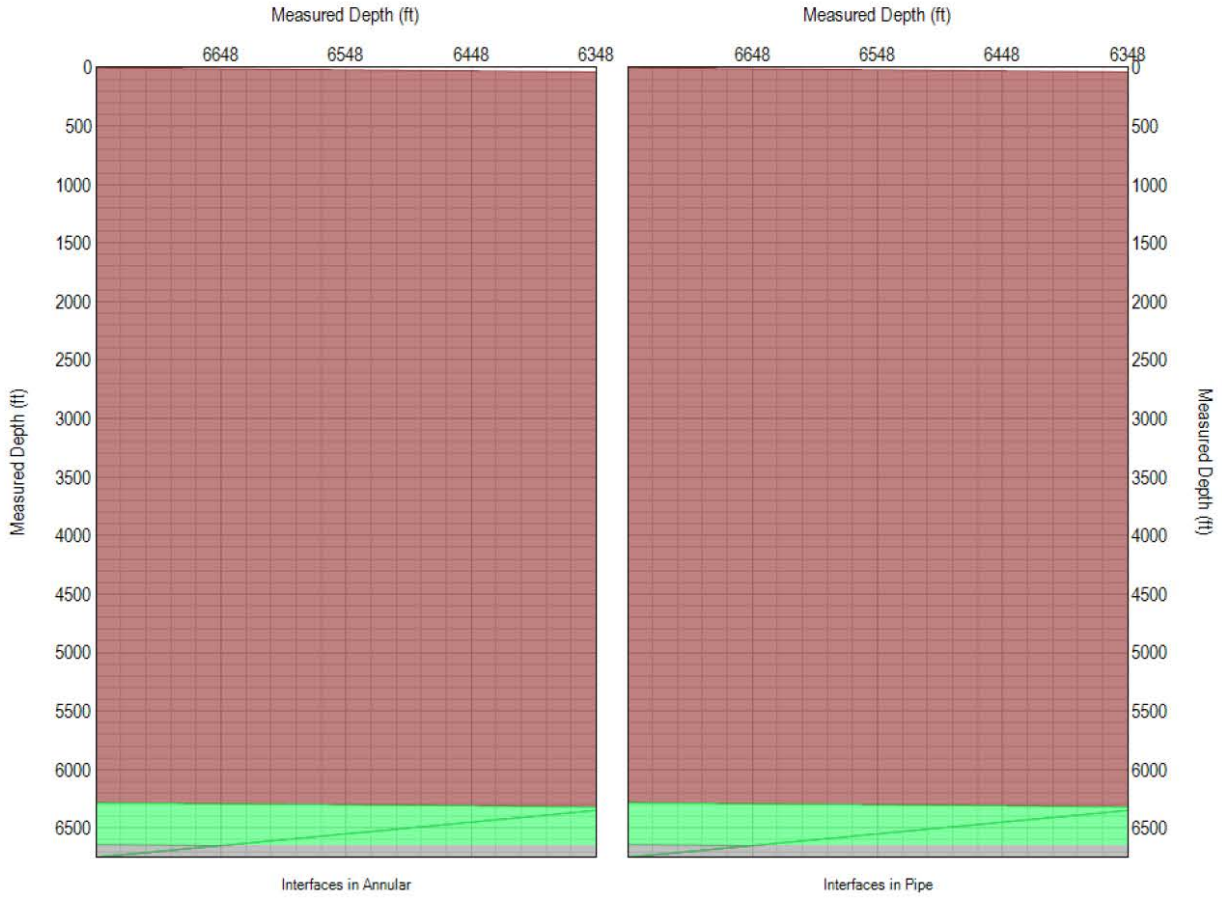
| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.1 | 6281.0 | 6280.9 | 111.6 | 9.40 |
| MUDPUSH Express | 6281.0 | 6638.6 | 357.6 | 6.4 | 12.00 |
| G P5 | 6638.6 | 6748.0 | 109.4 | 1.9 | 15.80 |

Note: Surface densities of compressible fluids are calculated at surface conditions, ie. P = 1 atm and T = 60.0 degF

# Static Pull Out Of Hole (POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP Depth: | 6348.0 ft | | Theoretical Top of Plug: | 6648.0 ft |
| POOH Length: | 400.0 ft | | Theoretical Plug Length: | 100.0 ft |
| POOH Speed: | 30-40ft/min | | Plug Bottom: | 6748.0 ft |
| **Top of uncontaminated cement after POOH:** | | | | **6648.0 ft** |
| **Uncontaminated cement length after POOH:** | | | | 100.0 ft |
| Contaminated cement length after POOH: | | | | 0.0 ft |

## POOH Results Summary




Note: Simulation assumes that fluids are free to balance themselves.

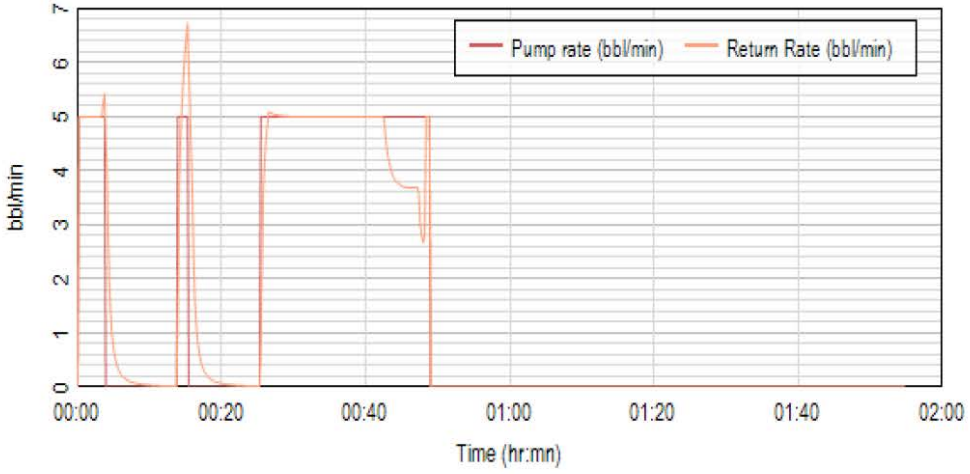
# Pumping Schedule

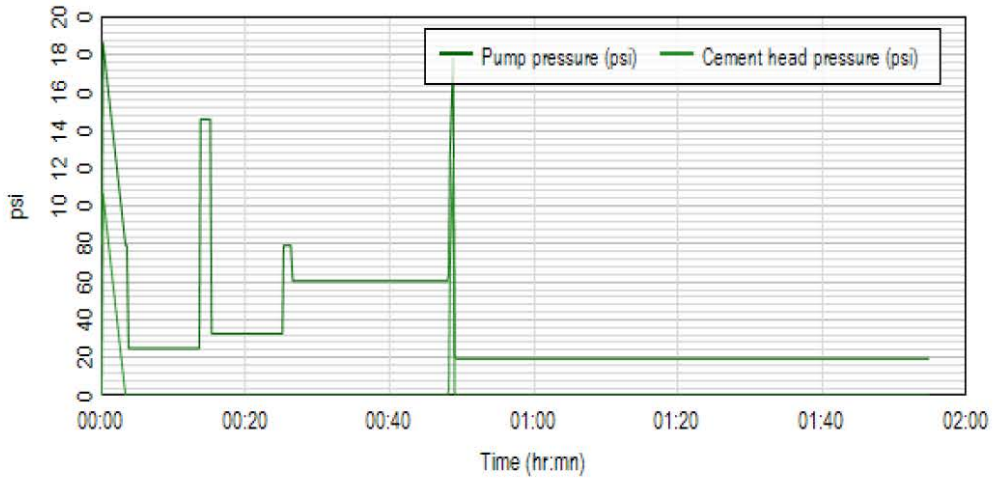
| Pumping Schedule | | | | | | |
|---|---|---|---|---|---|---|
| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Cum. Time hr:mn | Comment | Inj. Temp. degF |
| Pause | | | 00:00 | 00:00 | Circ to cool down well and cond mud 90min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.6 | 5.0 | 00:04 | 00:04 | | 80.0 |
| Plug | | | 00:10 | 00:14 | Foam ball | |
| G P5 | 7.6 | 5.0 | 00:02 | 00:15 | MinTT 3:40 | 80.0 |
| Plug | | | 00:10 | 00:25 | Foam ball | |
| MUDPUSH Express | 6.4 | 5.0 | 00:01 | 00:27 | | 80.0 |
| OBM | 111.6 | 5.0 | 00:22 | 00:49 | | 80.0 |
| Pause | | | 00:10 | 00:59 | Break cmt. lines | |
| Pause | | | 00:13 | 01:12 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:43 | 01:55 | Rig circ. pipe clean excess 350bbl @ 8bpm | |
| Pause | | | 00:00 | 01:55 | | |
| Shut-in | | | 00:00 | 01:55 | | |

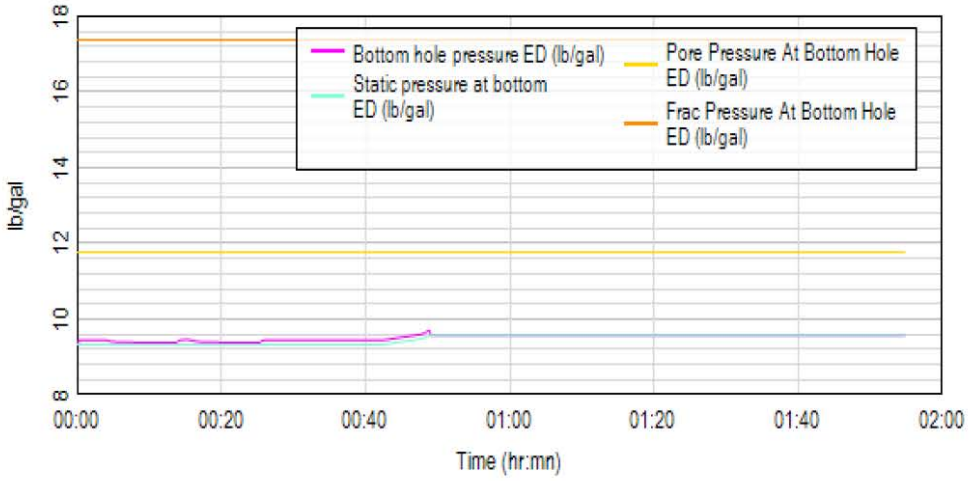
| | |
|---|---|
| Maximum Required Hydraulic Horsepower (HHP) | 22.9 hhp (at 00:00 hr:mn) |

| Displacement Volume Considerations | | |
|---|---|---|
| | Volume bbl | Variation bbl |
| Theoretical displacement volume | 111.6 | |
| Underdisplacement | | 0.0 |
| Final Displacement | 111.6 | |

Pauses in the jobs are only estimates – all efforts should be made during the operation to minimize these times.



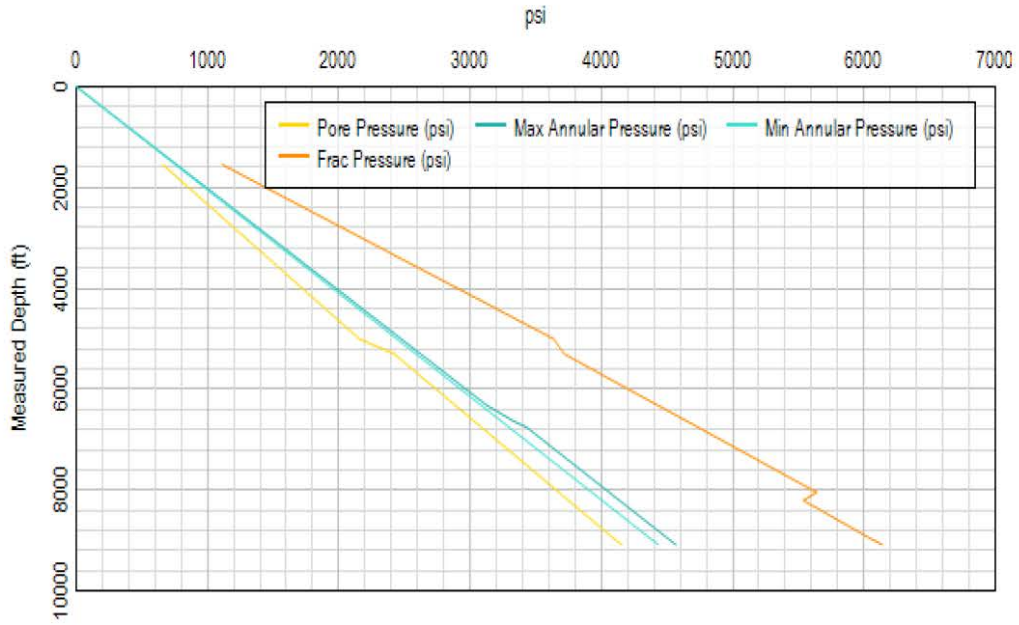

Pump pressure (psi)
Cement head pressure (psi)
psi
0 20 40 60 80 0 0 0 0 0 0 0 0 0 0
00:00 00:20 00:40 01:00 01:20 01:40 02:00
Time (hr:mn)


Bottom hole pressure ED (lb/gal)
Static pressure at bottom ED (lb/gal)
Pore Pressure At Bottom Hole ED (lb/gal)
Frac Pressure At Bottom Hole ED (lb/gal)
lb/gal
8 10 12 14 16 18
00:00 00:20 00:40 01:00 01:20 01:40 02:00
Time (hr:mn)

# Well Security

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 347 | 1551.5 | 00:15 |
| Success | Production/Influx | 96 | 1551.5 | 01:55 |
| Success | Burst | 9374 | 0.0 | 00:49 |
| Success | Collapse | 9372 | 4855.6 | 00:41 |

## Well Control



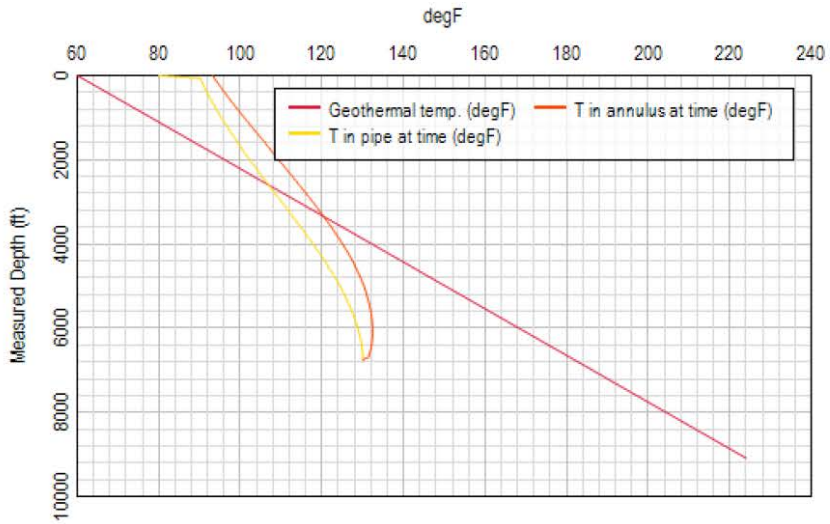
# Temperature Outputs

| | |
|---|---|
| BHST: | 181.9 degF |
| Static Temp at TOC: | 179.9 degF |

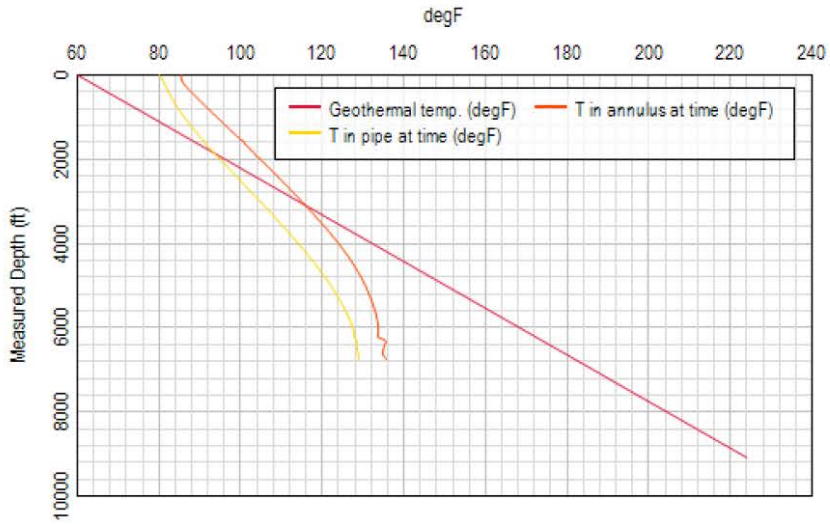
| | |
|---|---|
| Simulated BHCT: | 135.6 degF |
| Simulated HCT at TOC: | 134.7 degF |

Temperature simulation initial condition: Mud Circulation profile

## Initial Condition

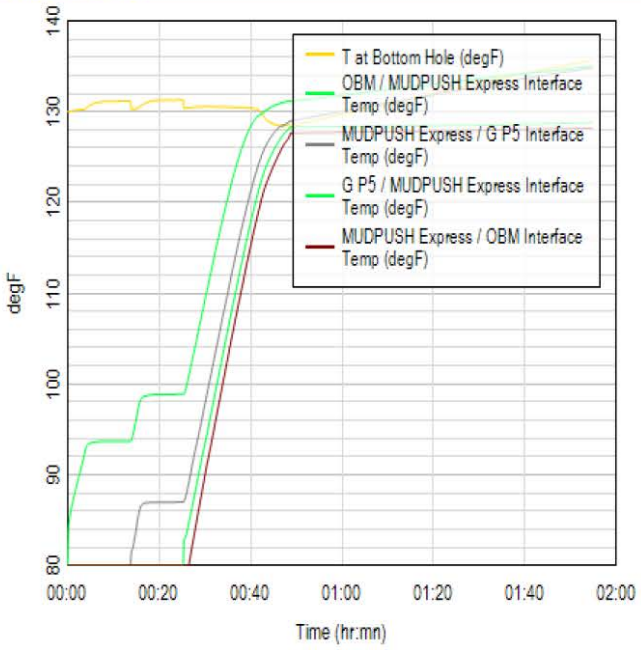



## Final Condition

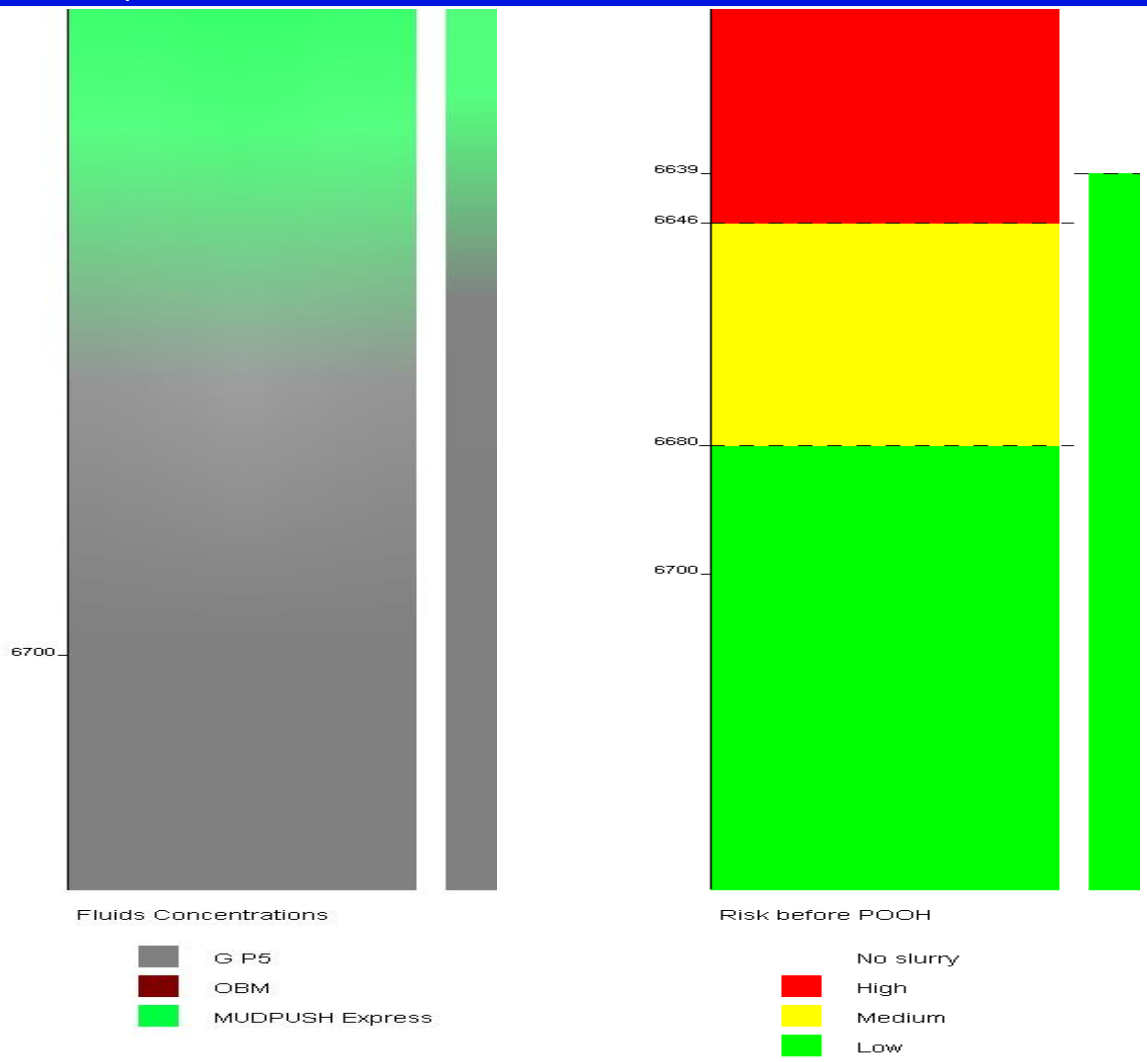



t = 01:55 hr:mn

## BHCT and Interface Temperatures



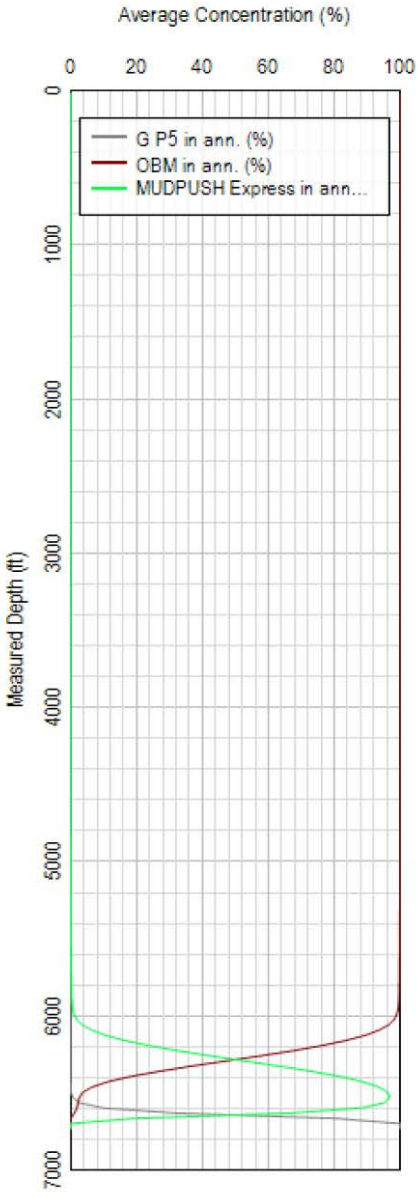
## WELLCLEAN III Maps



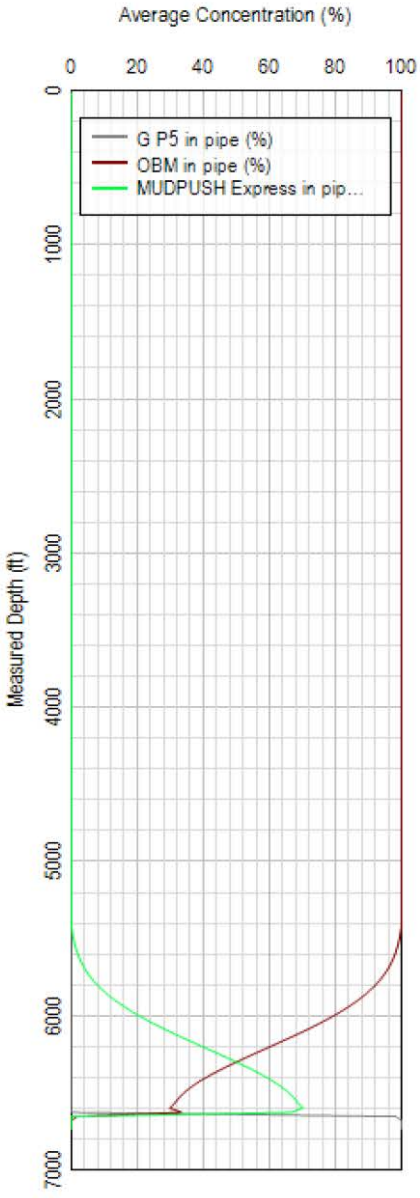

| | |
|---|---|
| **No cement slurry** | Slurry concentration is less than 10% (by unit of volume).<br>The concentration is below minimum threshold to consider that cement is present. |
| **High risk of contamination** | Slurry concentration is between 10% and 50% (by unit of volume).<br>There is no chance of finding hard cement when tagging within a few hours. |
| **Medium risk of contamination** | Slurry concentration is between 50% and 90% (by unit of volume).<br>It is possible to find some soft cement when tagging but it will most likely not be strong enough to kick off the well or even to provide a proper wellbore isolation. |
| **Low risk of contamination** | Slurry concentration is between 90% and 100% (by unit of volume).<br>Cement plug should be designed in such a way that the target of the top of cement should be within the 'green risk' zone. Hard cement should be found in that zone once compressive strength has developed, i.e. after the duration determined by the lab tests at downhole condition. |

## Fluid Concentrations before POOH

Average fluid concentration in annulus



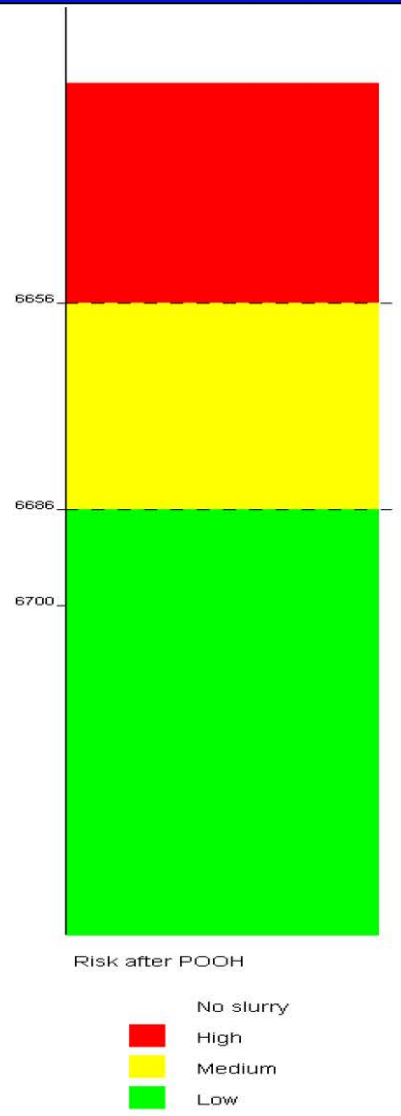

Average fluid concentration in pipe



# Final Contamination Risk (After POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP depth: | 6348.0 ft | | Theoretical Top of Plug: | 6648.0 ft |
| Theoretical Top of Plug (based on slurry volume) | | | | 6648.0 ft |
| Estimated TOC based on uncontaminated POOH simulation | | | | 6648.0 ft |
| Estimated TOC after POOH considering contamination during placement | | | | 6686.0 ft |

## Final Contamination Risk




Note: Simulation assumes that fluids are free to balance themselves

# Post-placement Circulation

Volume of compressible fluids is displayed at ambient conditions, ie. P = 1 atm and T = 60.0 degF

| | | | |
|---|---|---|---|
| DP Depth for Circulation: | 6348.0 ft | Designed TOC: | 6648.0 ft |

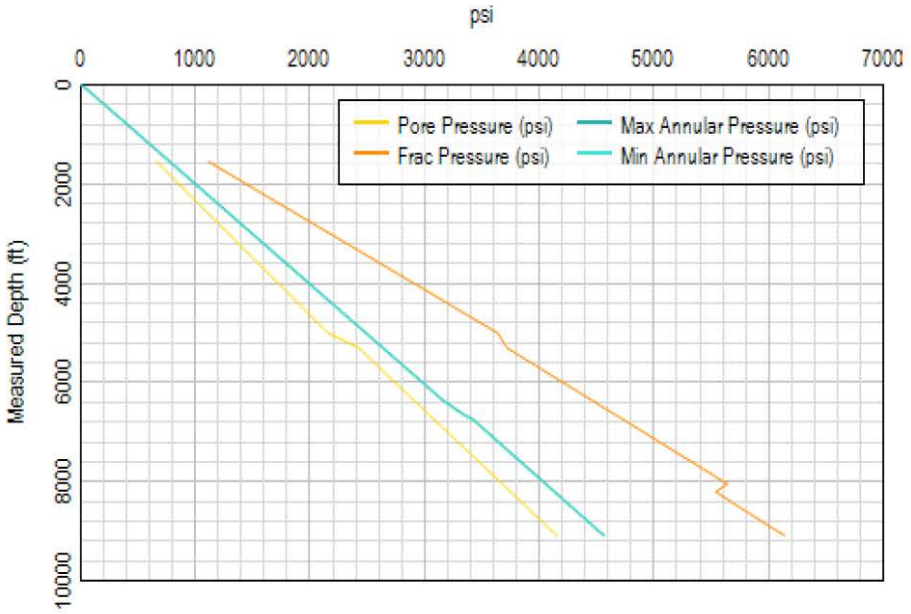
| | | | |
|---|---|---|---|
| Circulating Fluid: | OBM | Total Volume: | 350.0 bbl |
| Circulation Direction: | Direct | Number of Circulations: | 0.783 |

## Circulation Stages

| Stage | Pump Rate bbl/min | Duration hr:mn | Volume bbl | Back-pressure psi |
|---|---|---|---|---|
| OBM | 8.0 | 00:44 | 350.0 | 0 |

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 332 | 1551.5 | 00:41 |
| Success | Production/Influx | 108 | 1551.5 | 00:44 |
| Success | Burst | 9291 | 0.0 | 00:02 |
| Success | Collapse | 9550 | 6348.0 | 00:00 |

## Post-Placement Well Control






# Cypress M2
# Codell Plug
version 5 plug 6
1/22/2024

Rig : True Drilling 38

Prepared for:
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Tallgrass Energy
7202996780
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Prepared by:
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720 369 8051
jvaladez2@slb.com

# Job Objectives and Design Considerations

## Job Objectives

Mud company to spot 200' viscous pill below 7142' prior cement operations to support plug.
Circ. to cool down well and condition mud as per schedule.
Cement balanced plug to abandon Codell formation (7034-7091') from 7142-6984' (50' above Codell and 108' below, 158' plug length) in 8 3/4" OH (5% excess over caliper), no plan of tagging (expected TOC ~7011'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (6684') @ 40'/min rotating pipe slow and circulate to clean out excess.

## Acceptance Criteria

Pump cement plug as per design

### Operational Risk Statement

Cement plugs operations are complex to design and execute and this complexity should not be underestimated. Cement plugs operations should never be considered as a "routine" job. To successfully set cement plugs the same methodology used to design and execute primary cement jobs is required, which includes but is not limited to correct slurry design, mud-removal and placement design based on accurate well data. Cement plugs are remedial cementing treatments. The first design step is the determination of the actual problem to solve, i.e. define the purpose of setting a cement plug. The second step consists in defining the evaluation criteria: tag / no tag, positive pressure test, negative test, etc. Both steps allow for the proper specification of slurry properties and the determination of the adequate plug placement technique. This can result in additional laboratory tests as well as additional equipment requirements.

Nelson in Well Cementing (2006) discusses several factors that are key to successful plug cementing operations.
Displacement and under-displacement volumes play a critical role for the success of the job. The volumes specified in this program should be followed.
Fluid contamination/mixing during plug setting can jeopardize job success. To mitigate this risk, using a stable base for the plug, mechanical separators, and appropriate wait-on-cement-time is strongly recommended.
In case of a Kick-off Plug, proper knowledge of the BHA and application of correct drilling techniques are required to kick-off.

In case of any deviation from the approved job procedure, a Management of Change (MoC) is required. By raising a MoC to the appropriate level within the operator organization as well as within SLB, all the operational risks can be identified and addressed prior to execution of the cement plug.

# Plug Operation Summary

Overview of the cementing operation (temperatures, fluid types, rates and general notes)
**All depths (except water depth) take the rig floor as reference**

## Well & Rig Information

| | |
|---|---|
| Rig Type: | Land |

Objective: Mud company to spot 200' viscous pill below 7142' prior cement operations to support plug.
Circ. to cool down well and condition mud as per schedule.
Cement balanced plug to abandon Codell formation (7034-7091') from 7142-6984' (50' above Codell and 108' below, 158' plug length) in 8 3/4" OH (5% excess over caliper), no plan of tagging (expected TOC ~7011'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (6684') @ 40'/min rotating pipe slow and circulate to clean out excess.

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |
| Well Deviation: | 0.0 deg |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Placement & Post-Placement Conditions

| | |
|---|---|
| **Top:** | **6984.0 ft** |
| Length: | 158.0 ft |
| **Bottom:** | **7142.0 ft** |
| **Support:** | **VISCOUS PILL** |

| | |
|---|---|
| Mechanical Separator: | AHEAD AND BEHIND |
| Pipe Rotation / Reciprocation: | ROTATION |

| | |
|---|---|
| POOH Depth: | 6684.0 ft |
| POOH Speed: | 30-40FT/MIN |
| Circ. Rate: | 8.0 bbl/min |
| Circ. Direction: | Direct |

| | |
|---|---|
| String type and configuration: | OPEN ENDED |

## Design Considerations

| G P6 | |
|---|---|
| Cement Type: | Slurry |
| Slurry Dens.: | 15.80 lb/gal |

| MUDPUSH Express | |
|---|---|
| Spacer Type: | Spacer |
| Spacer Dens.: | 12.00 lb/gal |

| OBM | |
|---|---|
| Mud Type: | Oil Based Mud |
| Mud Dens.: | 9.40 lb/gal |

| | | | |
|---|---|---|---|
| **Volume Balance Model:** | Optimize Slurry & Spacer | Underdispl.: | 0.0 bbl |

## Pumping Schedule

| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Comment | Inj. Temp. degF |
|---|---|---|---|---|---|
| Pause | | | 00:00 | Circ to cool down well and cond mud 90min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.6 | 5.0 | 00:04 | | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| G P6 | 11.9 | 5.0 | 00:02 | MinTT 3:44 | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| MUDPUSH Express | 6.4 | 5.0 | 00:01 | | 80.0 |
| OBM | 117.4 | 5.0 | 00:23 | | 80.0 |

| | | | | | |
|---|---|---|---|---|---|
| Pause | | | 00:10 | Break cmt. lines | |
| Pause | | | 00:13 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:46 | Rig circ. pipe clean excess 368bbl @ 8bpm | |
| Pause | | | 00:00 | | |
| Shut-in | | | 00:00 | | |

| Temperature Simulation | | | | |
|---|---|---|---|---|
| Pre-job Circ. Rate: | 8 bbl/min | | BHST: | 189.0 degF |
| Pre-job Circ. Time: | 90MIN | | Simulated BHCT: | 142.1 degF |

# Well Data Summary

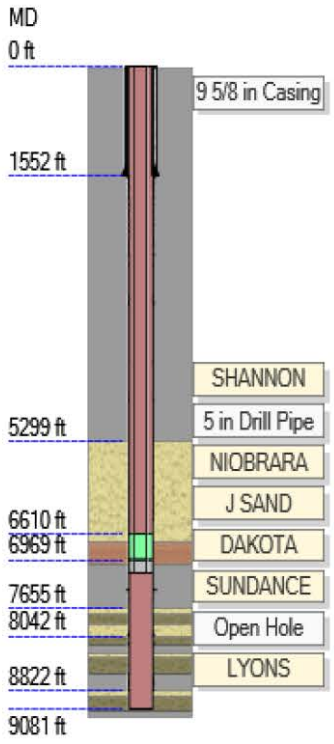
The cementing program incorporates the following data:
**All depths (except water depth) take the rig floor as reference**

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Tubulars and Casing Hardware

| | MD ft | OD in | Weight lb/ft | Grade | ID in | Thread | Collapse psi | Burst psi | Joint ft |
|---|---|---|---|---|---|---|---|---|---|
| Prev Casing | 1551.5 | 9 5/8 | 40.0 | J-55 | 8.835 | | 2570 | 3950 | 1.0 |
| Workstring | 7142.0 | 5 | 19.5 | E75 | 4.276 | | 10000 | 9500 | 40.0 |



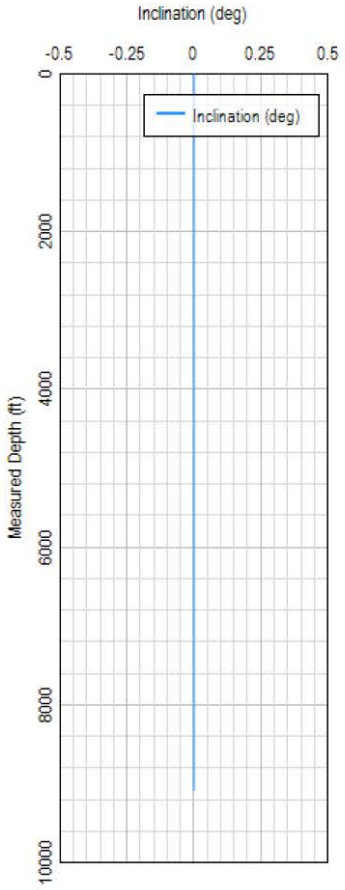

## Open Hole

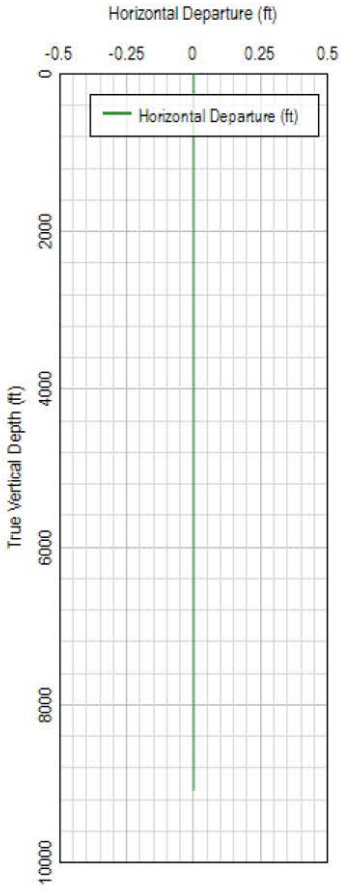
| | |
|---|---|
| Total OH Volume: | 574.0 bbl |
| Minimum Diameter: | 8.473 in |
| Maximum Diameter: | 12.776 in |

| | |
|---|---|
| Mean Diameter: | 8.750 in |
| Mean Ann. Excess: | 5.000 % |
| Mean Eq. Diameter: | 8.859 in |

Note : OH caliper was uploaded.

## Directional Survey




**Note:** Hole assumed vertical

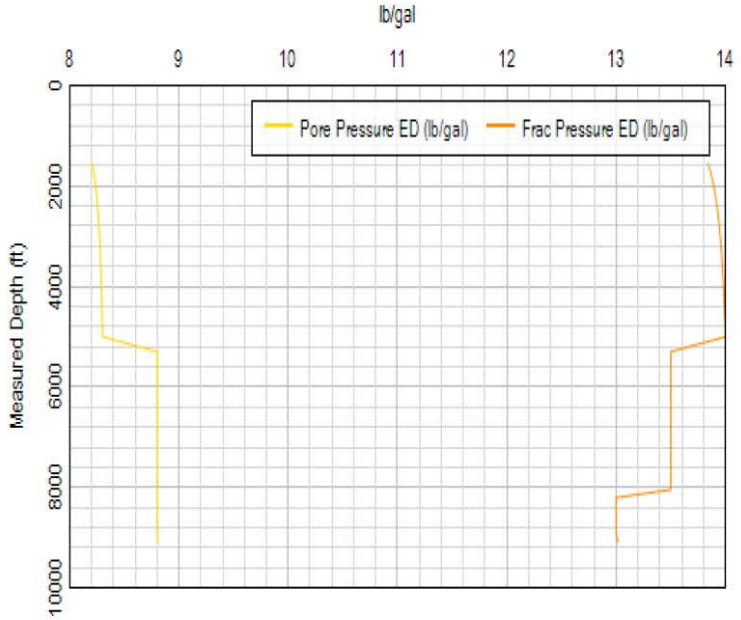
## Formation

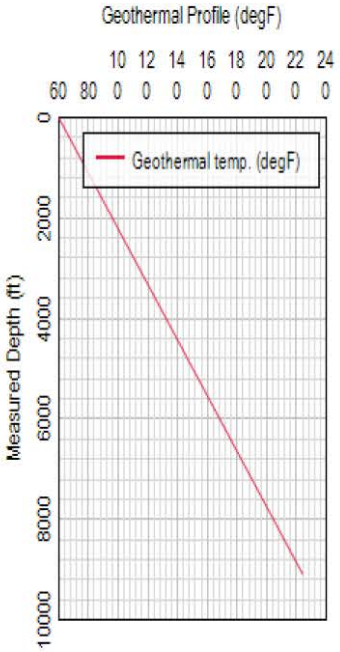
| Top MD ft | Bottom MD ft | Bottom TVD ft | Frac Top ED lb/gal | Frac Bottom ED lb/gal | Pore Top ED lb/gal | Pore Bottom ED lb/gal | Lithology | Res. Fluid | Name |
|---|---|---|---|---|---|---|---|---|---|
| 25.5 | 5000.0 | 5000.0 | 0.00 | 14.00 | 0.00 | 8.30 | | | |
| 5000.0 | 5299.0 | 5299.0 | 14.00 | 13.50 | 8.30 | 8.80 | | | |
| 5299.0 | 6711.0 | 6711.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | SHANNON |
| 6711.0 | 7048.0 | 7048.0 | 13.50 | 13.50 | 8.80 | 8.80 | Shale | | NIOBRARA |
| 7048.0 | 7250.0 | 7250.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7250.0 | 7655.0 | 7655.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7655.0 | 7734.0 | 7734.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | J SAND |
| 7734.0 | 7894.0 | 7894.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7894.0 | 8042.0 | 8042.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | DAKOTA |
| 8042.0 | 8200.0 | 8200.0 | 13.50 | 13.00 | 8.80 | 8.80 | | | |
| 8200.0 | 8274.0 | 8274.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8274.0 | 8336.0 | 8336.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | SUNDANCE |
| 8336.0 | 8500.0 | 8500.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8500.0 | 8600.0 | 8600.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8600.0 | 8682.0 | 8682.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8682.0 | 8822.0 | 8822.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8822.0 | 8891.0 | 8891.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | LYONS |
| 8891.0 | 9081.0 | 9081.0 | 13.00 | 13.01 | 8.80 | 8.81 | | | |

## Temperature

| Name | Top MD ft | Bottom MD ft | Bottom TVD ft | Temp. degF | Temp. Gradient degF/100ft | Temp. Rel. Gradient degF/100ft | |
|---|---|---|---|---|---|---|---|
| Surface | 0.0 | 0.0 | 0.0 | 60.0 | 0.00 | | |
| Rock | 0.0 | 6748.0 | 6748.0 | 161.9 | 1.81 | 1.81 | |
| Rock | 6748.0 | 6798.0 | 6798.0 | 162.8 | 1.81 | 1.81 | |
| BHST | 6798.0 | 7142.0 | 7142.0 | 189.0 | 1.81 | 1.81 | |
| Rock | 7142.0 | 9081.0 | 9081.0 | 224.0 | 1.81 | 1.81 | |

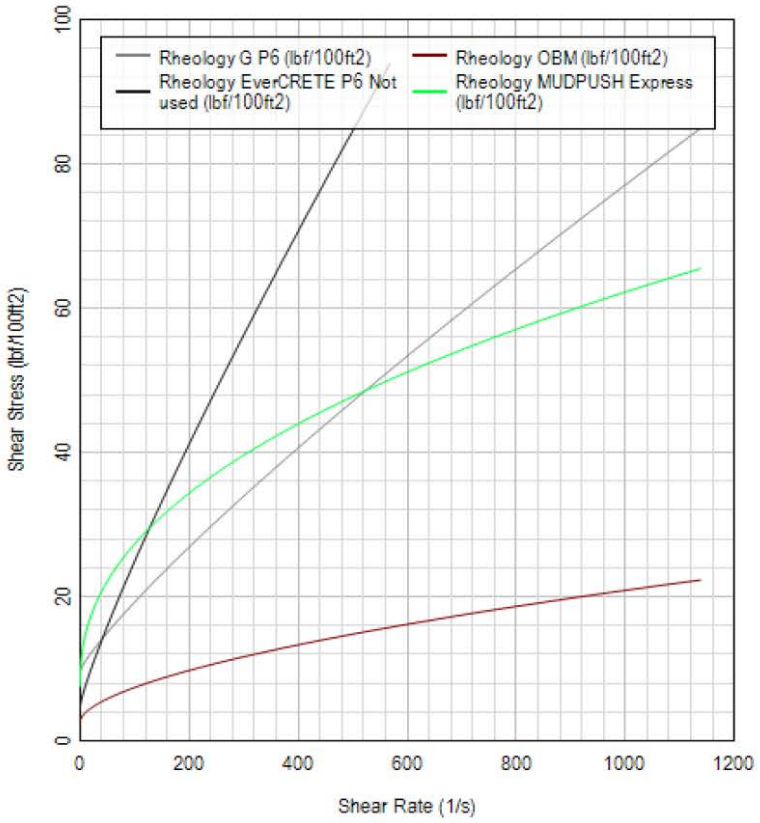
**Source of temperature data:** 224degF at BH from 3 different SLB WL Logs, confirmed with client



# Fluids Summary

| Fluids | | | | | | |
|---|---|---|---|---|---|---|
| Type | Name | Density lb/gal | Conditions | K lbf.s^n/ft2 | n | Ty lbf/100ft2 |
| Drilling Fluid | OBM | 9.40 | Downhole 190.0 degF | 3.03E-3 | 0.589 | 2.59 |
| Spacer | MUDPUSH Express | 12.00 | Downhole 190.0 degF WND 2023-153 | 2.36E-2 | 0.449 | 7.58 |
| Slurry | G P6 | 15.80 | Downhole 171.0 degF CWY 2022-301 | 1.86E-3 | 0.852 | 9.20 |




| Fluid Density and Rheology Tolerance |
|---|
| **Mud** – properties to be verified prior to job with mud engineer, contact engineer onshore if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg rheology difference from planned : +/- 10% |
| **Spacer** – properties to be verified prior to job, see contingency plans if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg |
| **Slurry** – cement slurry should be mixed within the range described below, see contingency plans if there is mismatch between designed density and slurry volume<br>density difference from planned : +/- 0.2 ppg |

# Mud Circulation

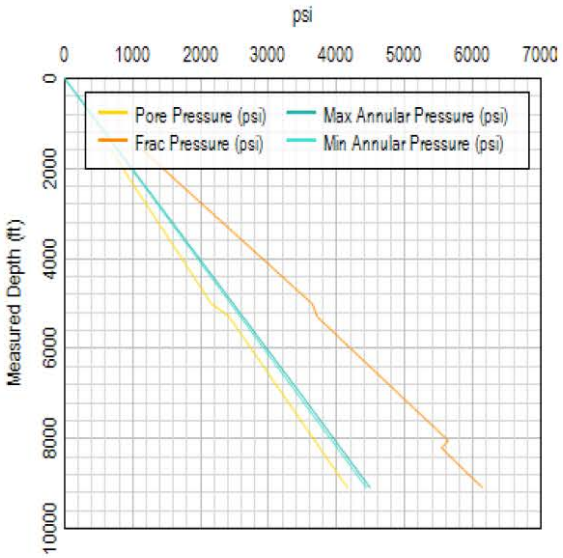
| | |
|---|---|
| Fluid | OBM |
| Number of Circulations | 1.434 |
| Total Volume at Ambient Temperature | 720.0 bbl |
| Ambient Temperature | 80.0 degF |
| Correction Slope | 0.700 |

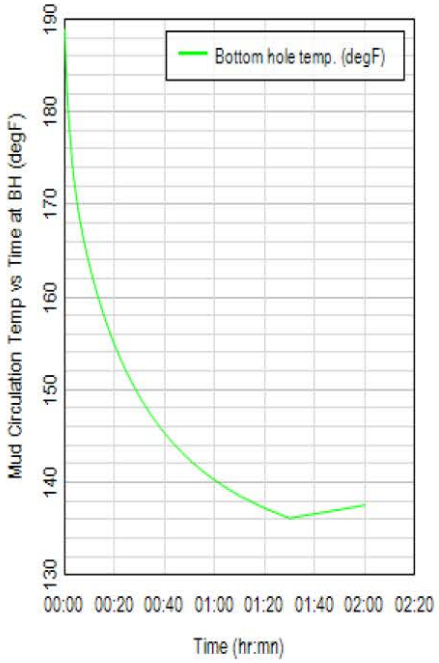
**Pumping Stages**

| Fluid | Pump Rate bbl/min | Duration hr:mn | Volume bbl |
|---|---|---|---|
| OBM | 8.0 | 01:30 | 720.0 |
| Pause | | 00:30 | |

**Well Security**

| Status | Description | Min Differential Pressure psi | At Depth ft | At Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 346 | 1551.5 | 01:30 |
| Success | Production/Influx | 96 | 1551.5 | 02:00 |
| Success | Burst | 9280 | 0.0 | 00:00 |
| Success | Collapse | 9495 | 7142.0 | 02:00 |



# Fluid Placement

## Volume Balance Objectives

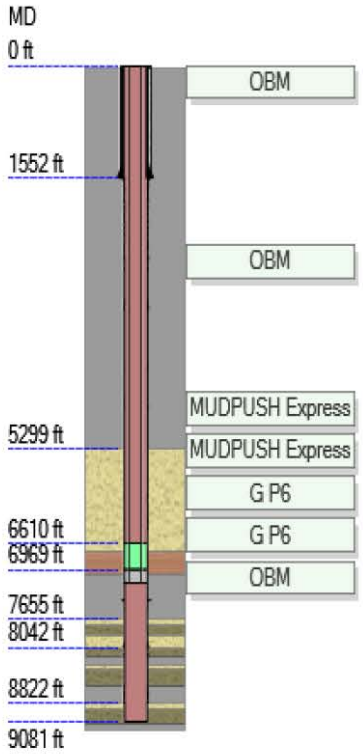
Volume Balance Model: **Optimize Slurry & Spacer**

| | | | | | |
|---|---|---|---|---|---|
| Original Fluid: | OBM | Rat Hole Fluid: | OBM | Displ. Fluid: | OBM |
| Top Spacer: | MUDPUSH Express | set Total Volume to: | 25.0 bbl | | |
| Top Slurry: | G P6 | set Top MD to: | 6984.0 ft | | |

Annulus is **not** filled during POOH.

## Volume Balance Results

| | | | | | |
|---|---|---|---|---|---|
| String Volume: | 126.9 bbl | Underdispl.: | -0.0 bbl | Displ. Volume: | 117.4 bbl |
| TOC after POOH: | 6984.0 ft | Cement Length after POOH: | 158.0 ft | | |




## Fluid Placement in Annulus

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.0 | 6610.3 | 6610.3 | 348.0 | 9.40 |
| MUDPUSH Express | 6610.3 | 6968.9 | 358.6 | 18.6 | 12.00 |
| G P6 | 6968.9 | 7142.0 | 173.1 | 8.8 | 15.80 |

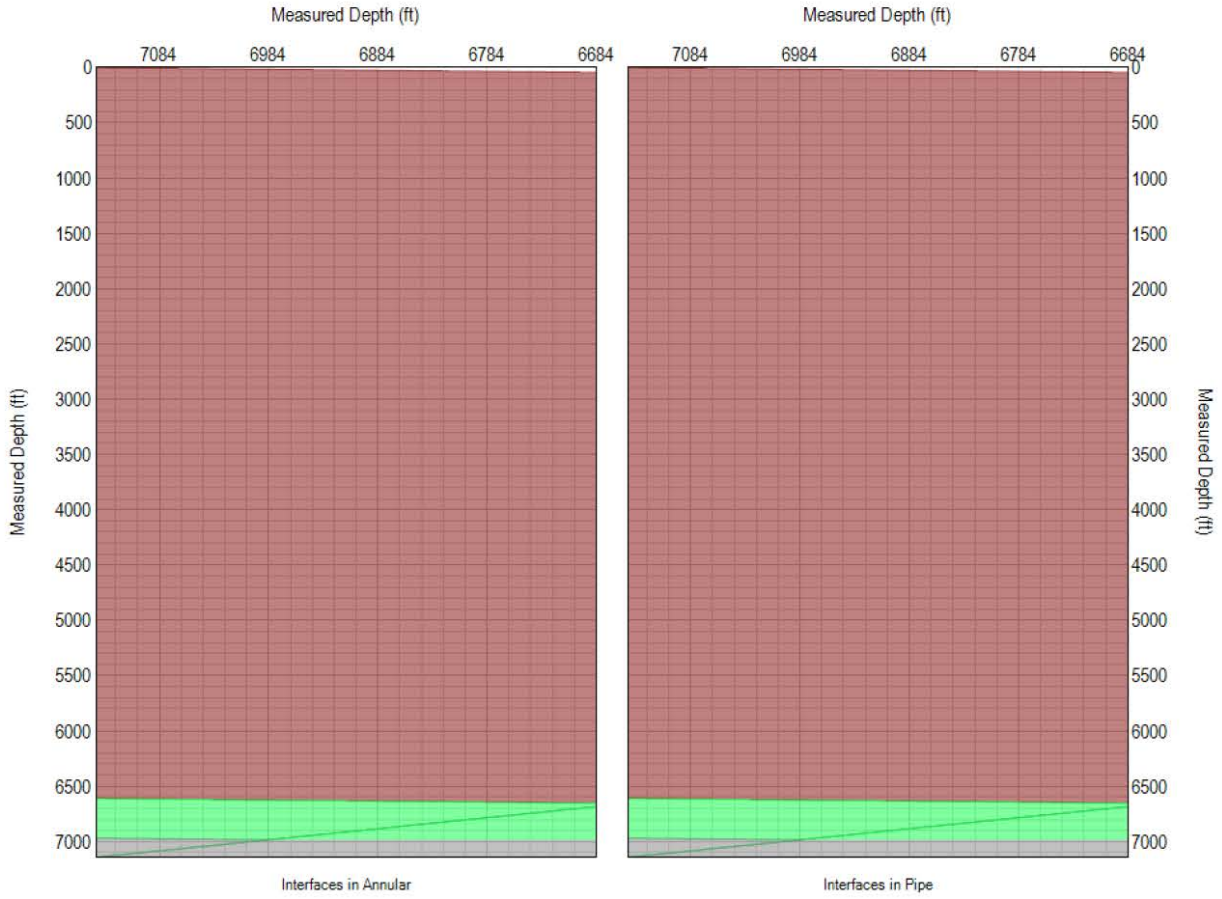
## Fluid Placement in Pipe

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.1 | 6609.6 | 6609.5 | 117.4 | 9.40 |
| MUDPUSH Express | 6609.6 | 6969.1 | 359.5 | 6.4 | 12.00 |
| G P6 | 6969.1 | 7142.0 | 172.9 | 3.1 | 15.80 |

# Static Pull Out Of Hole (POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP Depth: | 6684.0 ft | | Theoretical Top of Plug: | 6984.0 ft |
| POOH Length: | 458.0 ft | | Theoretical Plug Length: | 158.0 ft |
| POOH Speed: | 30-40ft/min | | Plug Bottom: | 7142.0 ft |
| **Top of uncontaminated cement after POOH:** | | | | **6984.0 ft** |
| **Uncontaminated cement length after POOH:** | | | | 158.0 ft |
| Contaminated cement length after POOH: | | | | 0.0 ft |

## POOH Results Summary




Note: Simulation assumes that fluids are free to balance themselves.

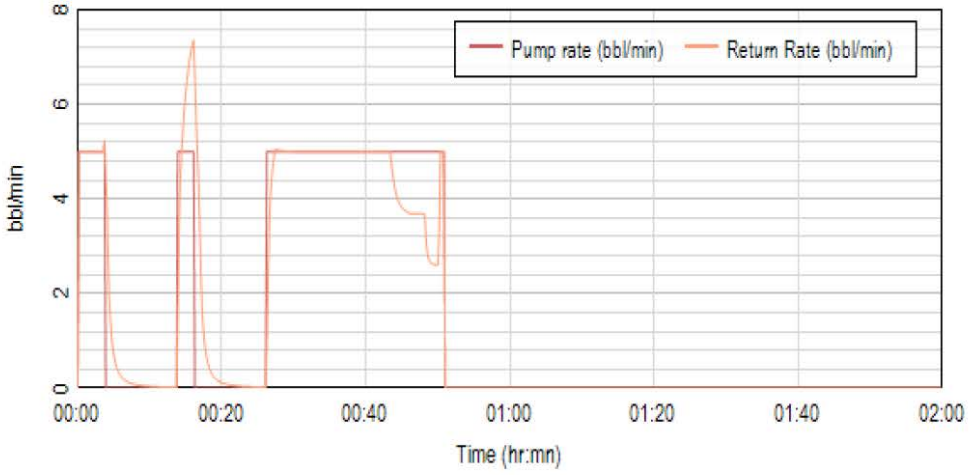
# Pumping Schedule

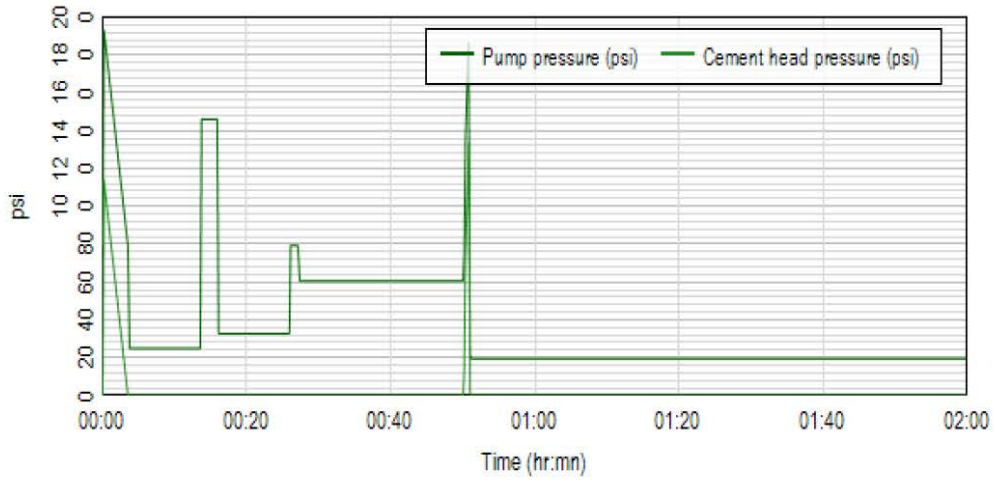
| Pumping Schedule | | | | | | |
|---|---|---|---|---|---|---|
| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Cum. Time hr:mn | Comment | Inj. Temp. degF |
| Pause | | | 00:00 | 00:00 | Circ to cool down well and cond mud 90min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.6 | 5.0 | 00:04 | 00:04 | | 80.0 |
| Plug | | | 00:10 | 00:14 | Foam ball | |
| G P6 | 11.9 | 5.0 | 00:02 | 00:16 | MinTT 3:44 | 80.0 |
| Plug | | | 00:10 | 00:26 | Foam ball | |
| MUDPUSH Express | 6.4 | 5.0 | 00:01 | 00:27 | | 80.0 |
| OBM | 117.4 | 5.0 | 00:23 | 00:51 | | 80.0 |
| Pause | | | 00:10 | 01:01 | Break cmt. lines | |
| Pause | | | 00:13 | 01:14 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:46 | 02:00 | Rig circ. pipe clean excess 368bbl @ 8bpm | |
| Pause | | | 00:00 | 02:00 | | |
| Shut-in | | | 00:00 | 02:00 | | |

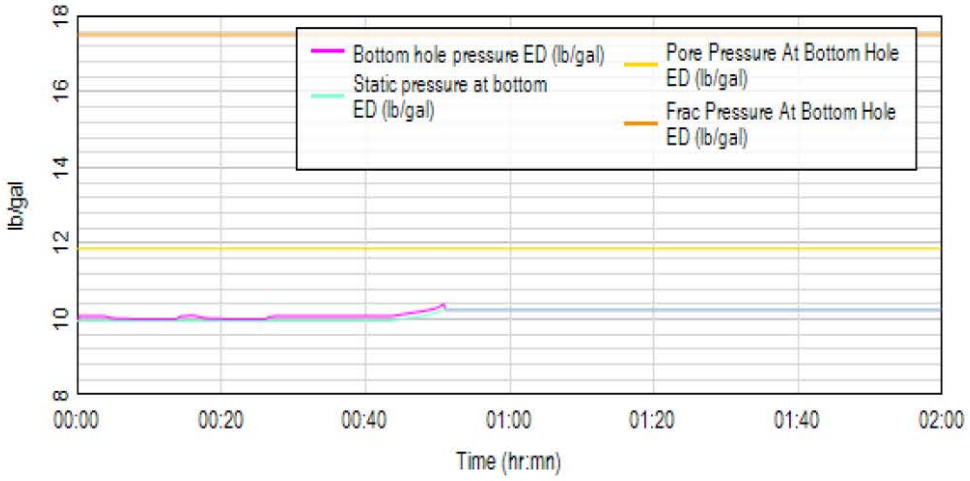
| | |
|---|---|
| Maximum Required Hydraulic Horsepower (HHP) | 23.7 hhp (at 00:00 hr:mn) |

| Displacement Volume Considerations | | |
|---|---|---|
| | Volume bbl | Variation bbl |
| Theoretical displacement volume | 117.4 | |
| Underdisplacement | | -0.0 |
| Final Displacement | 117.4 | |

Pauses in the jobs are only estimates – all efforts should be made during the operation to minimize these times.



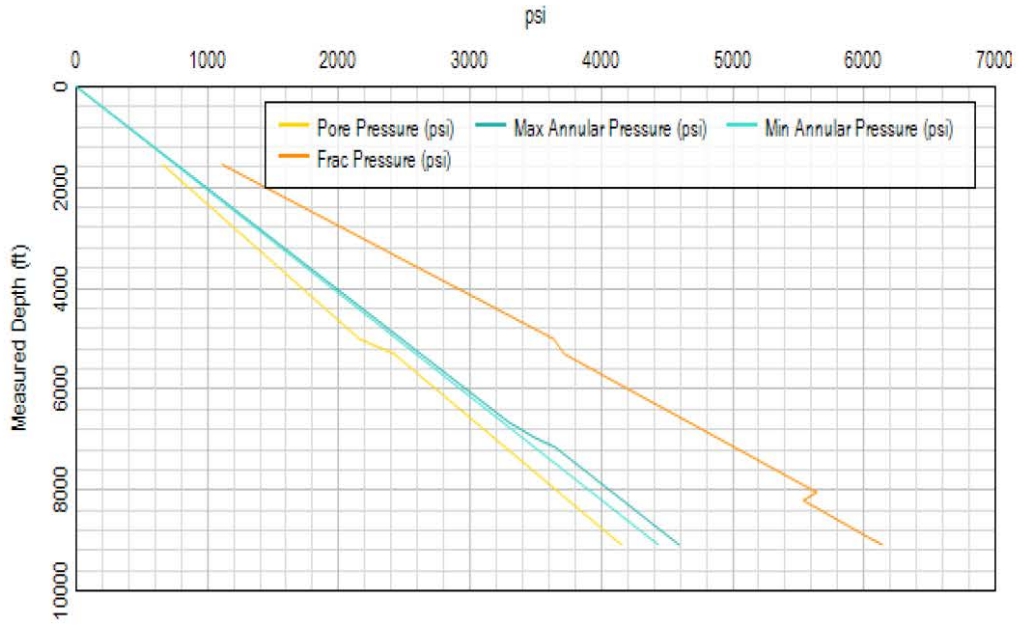

Pump pressure (psi)
Cement head pressure (psi)
psi
0
20
40
60
80
0
10
12
14
16
18
20
00:00
00:20
00:40
01:00
01:20
01:40
02:00
Time (hr:mn)


Bottom hole pressure ED (lb/gal)
Static pressure at bottom ED (lb/gal)
Pore Pressure At Bottom Hole ED (lb/gal)
Frac Pressure At Bottom Hole ED (lb/gal)
lb/gal
8
10
12
14
16
18
00:00
00:20
00:40
01:00
01:20
01:40
02:00
Time (hr:mn)

# Well Security

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 347 | 1551.5 | 00:16 |
| Success | Production/Influx | 96 | 1551.5 | 02:00 |
| Success | Burst | 9366 | 0.0 | 00:51 |
| Success | Collapse | 9293 | 5019.7 | 00:42 |

## Well Control



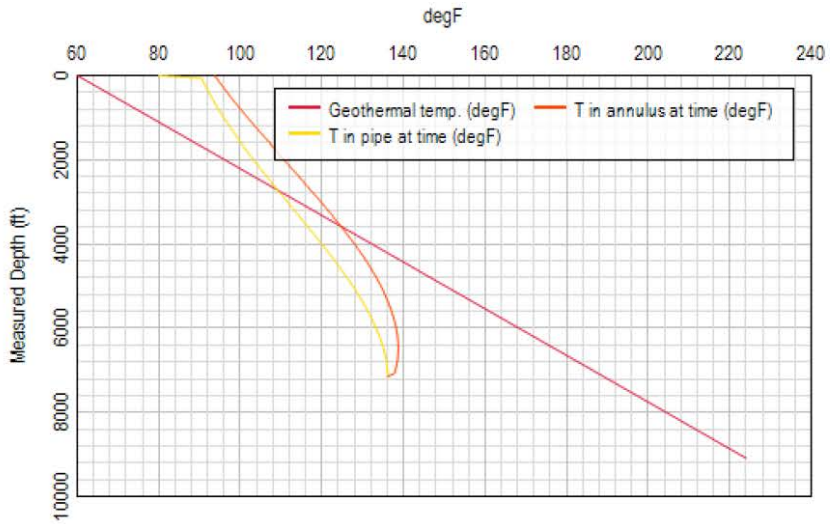
# Temperature Outputs

| | |
|---|---|
| BHST: | 189.0 degF |
| Static Temp at TOC: | 185.9 degF |

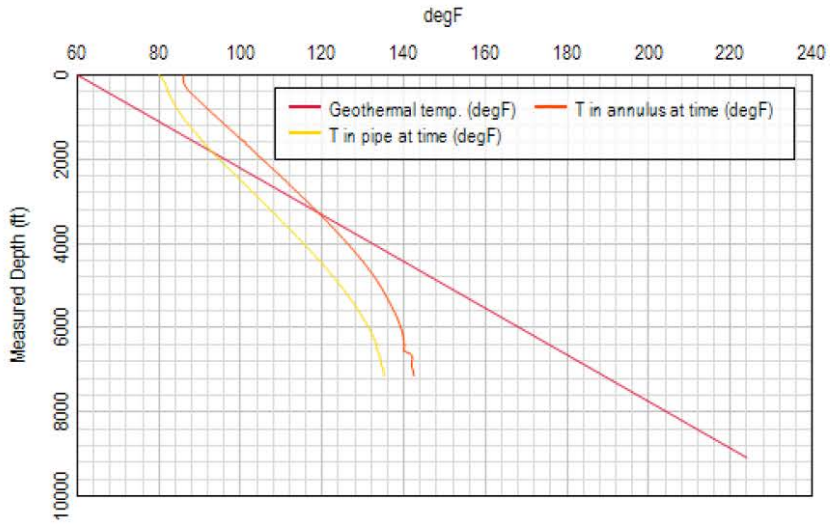
| | |
|---|---|
| Simulated BHCT: | 142.1 degF |
| Simulated HCT at TOC: | 141.7 degF |

Temperature simulation initial condition: Mud Circulation profile

## Initial Condition

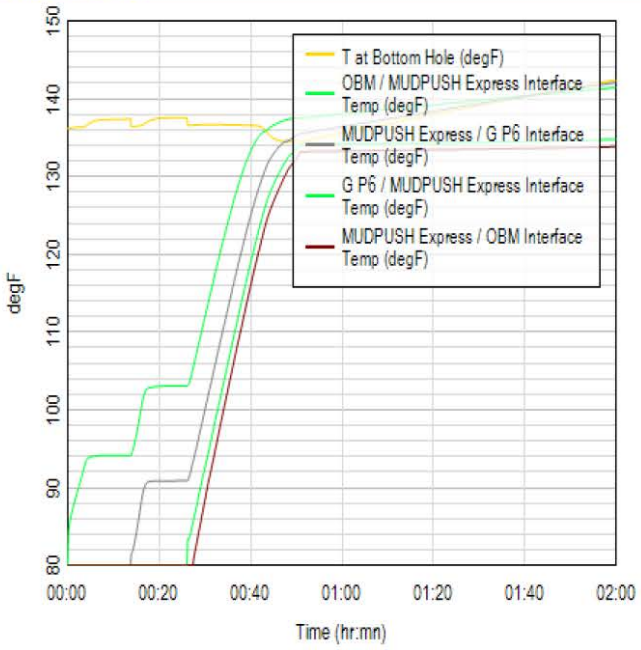



## Final Condition

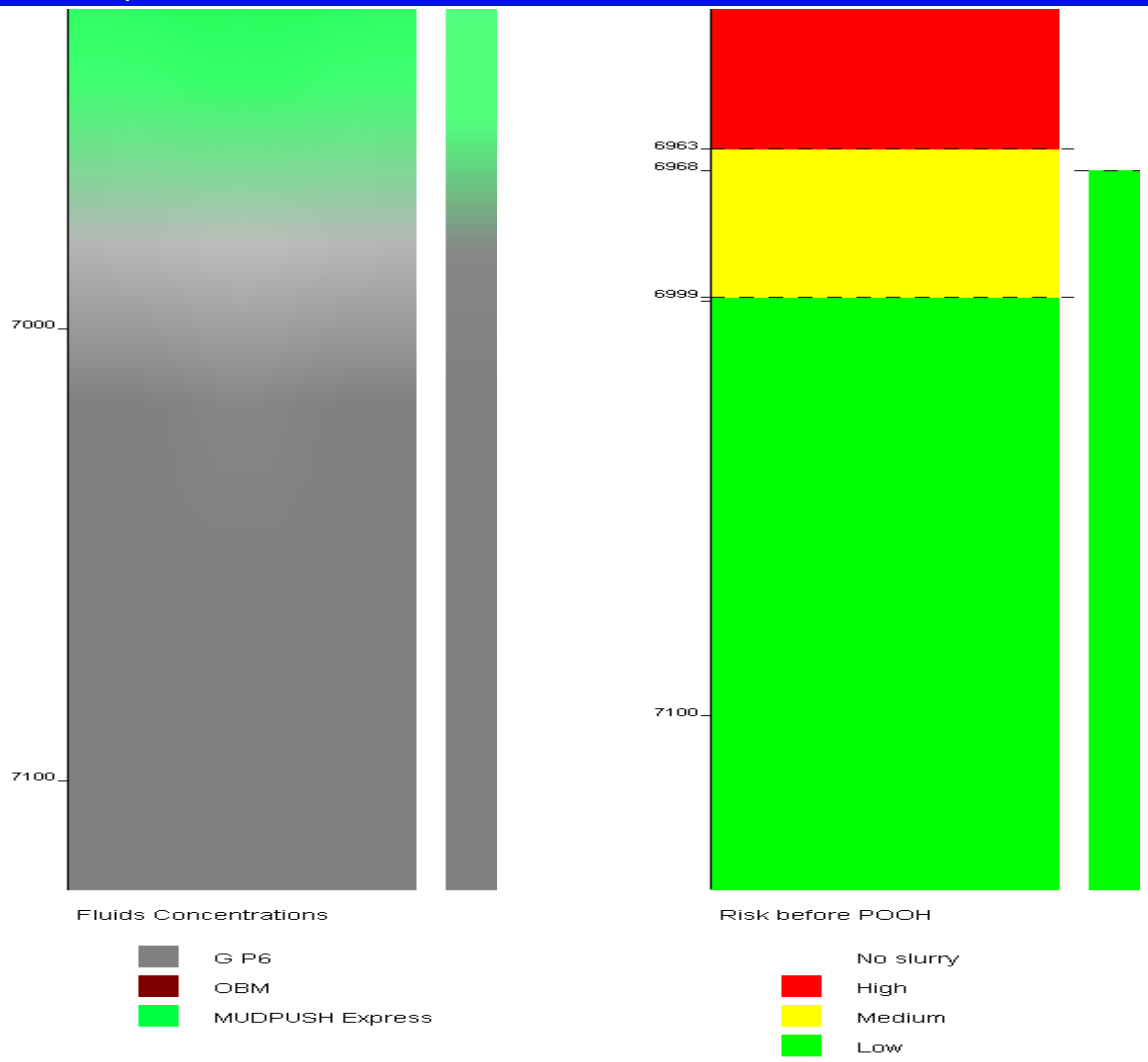



t = 02:00 hr:mn

## BHCT and Interface Temperatures



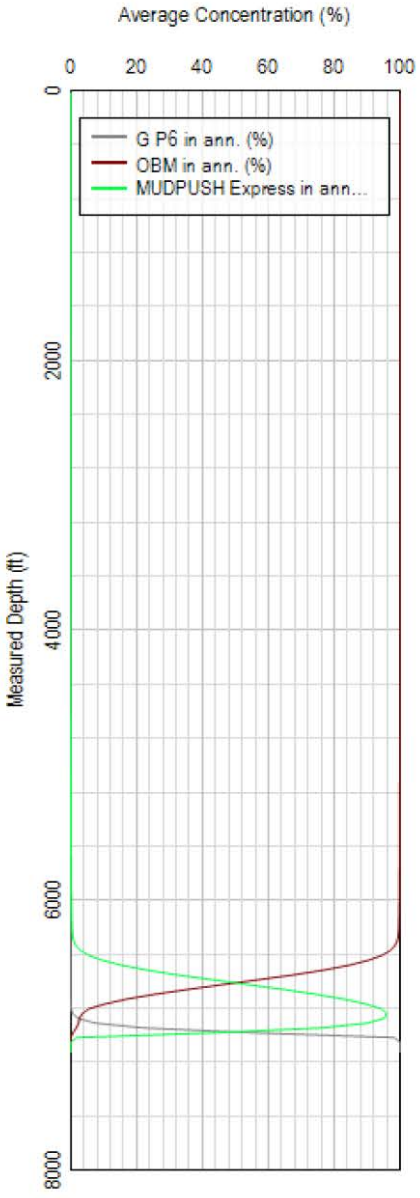
## WELLCLEAN III Maps



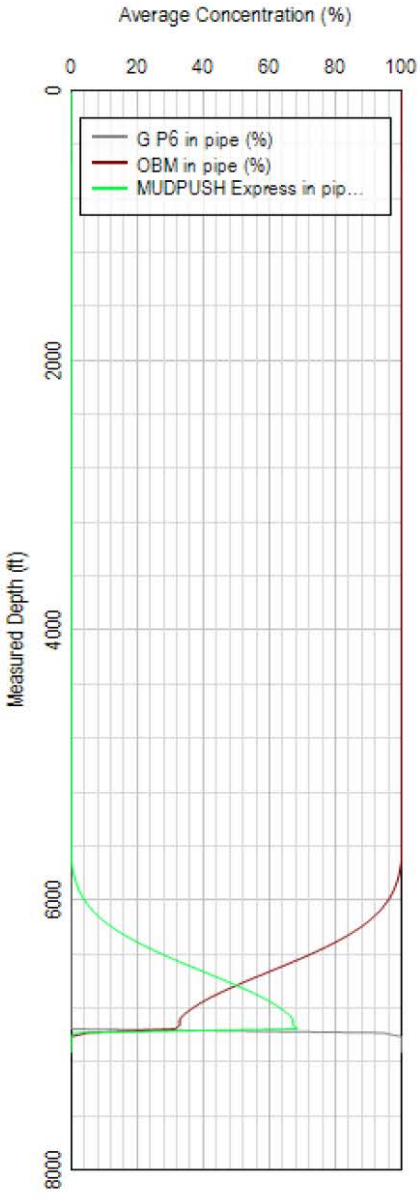

| | |
|---|---|
| **No cement slurry** | Slurry concentration is less than 10% (by unit of volume).<br>The concentration is below minimum threshold to consider that cement is present. |
| **High risk of contamination** | Slurry concentration is between 10% and 50% (by unit of volume).<br>There is no chance of finding hard cement when tagging within a few hours. |
| **Medium risk of contamination** | Slurry concentration is between 50% and 90% (by unit of volume).<br>It is possible to find some soft cement when tagging but it will most likely not be strong enough to kick off the well or even to provide a proper wellbore isolation. |
| **Low risk of contamination** | Slurry concentration is between 90% and 100% (by unit of volume).<br>Cement plug should be designed in such a way that the target of the top of cement should be within the 'green risk' zone. Hard cement should be found in that zone once compressive strength has developed, i.e. after the duration determined by the lab tests at downhole condition. |

## Fluid Concentrations before POOH

Average fluid concentration in annulus



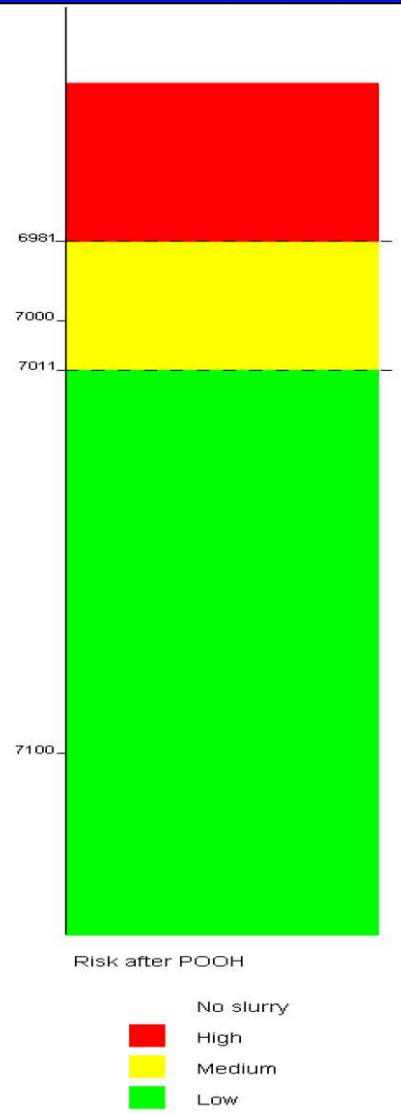

Average fluid concentration in pipe



# Final Contamination Risk (After POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP depth: | 6684.0 ft | | Theoretical Top of Plug: | 6984.0 ft |
| Theoretical Top of Plug (based on slurry volume) | | | | 6984.0 ft |
| Estimated TOC based on uncontaminated POOH simulation | | | | 6984.0 ft |
| Estimated TOC after POOH considering contamination during placement | | | | 7011.5 ft |

## Final Contamination Risk




Note: Simulation assumes that fluids are free to balance themselves

# Post-placement Circulation

Volume of compressible fluids is displayed at ambient conditions, ie. P = 1 atm and T = 60.0 degF

| | | | |
|---|---|---|---|
| DP Depth for Circulation: | 6684.0 ft | Designed TOC: | 6984.0 ft |

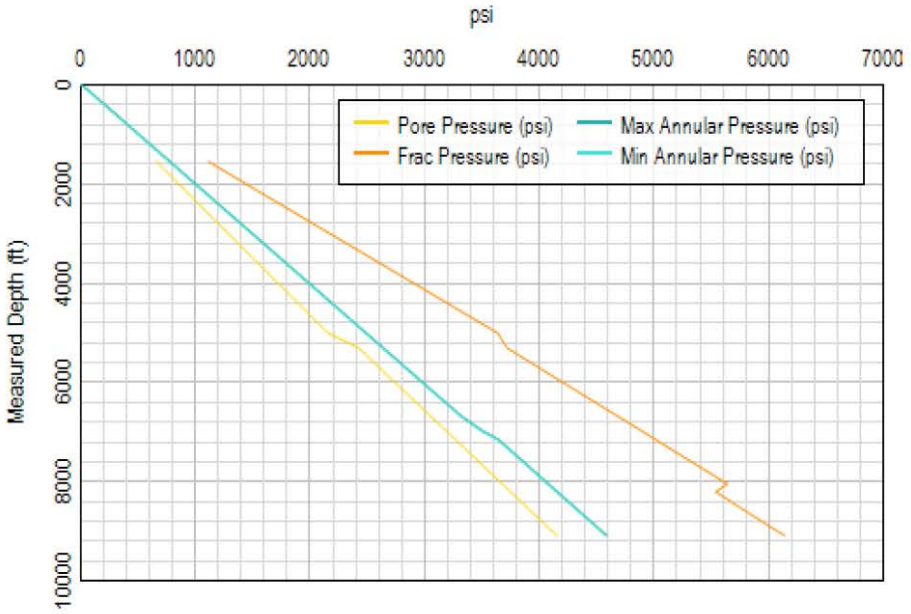
| | | | |
|---|---|---|---|
| Circulating Fluid: | OBM | Total Volume: | 368.0 bbl |
| Circulation Direction: | Direct | Number of Circulations: | 0.782 |

## Circulation Stages

| Stage | Pump Rate bbl/min | Duration hr:mn | Volume bbl | Back-pressure psi |
|---|---|---|---|---|
| OBM | 8.0 | 00:46 | 368.0 | 0 |

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 331 | 1551.5 | 00:43 |
| Success | Production/Influx | 108 | 1551.5 | 00:46 |
| Success | Burst | 9279 | 0.0 | 00:04 |
| Success | Collapse | 9526 | 6684.0 | 00:00 |

## Post-Placement Well Control



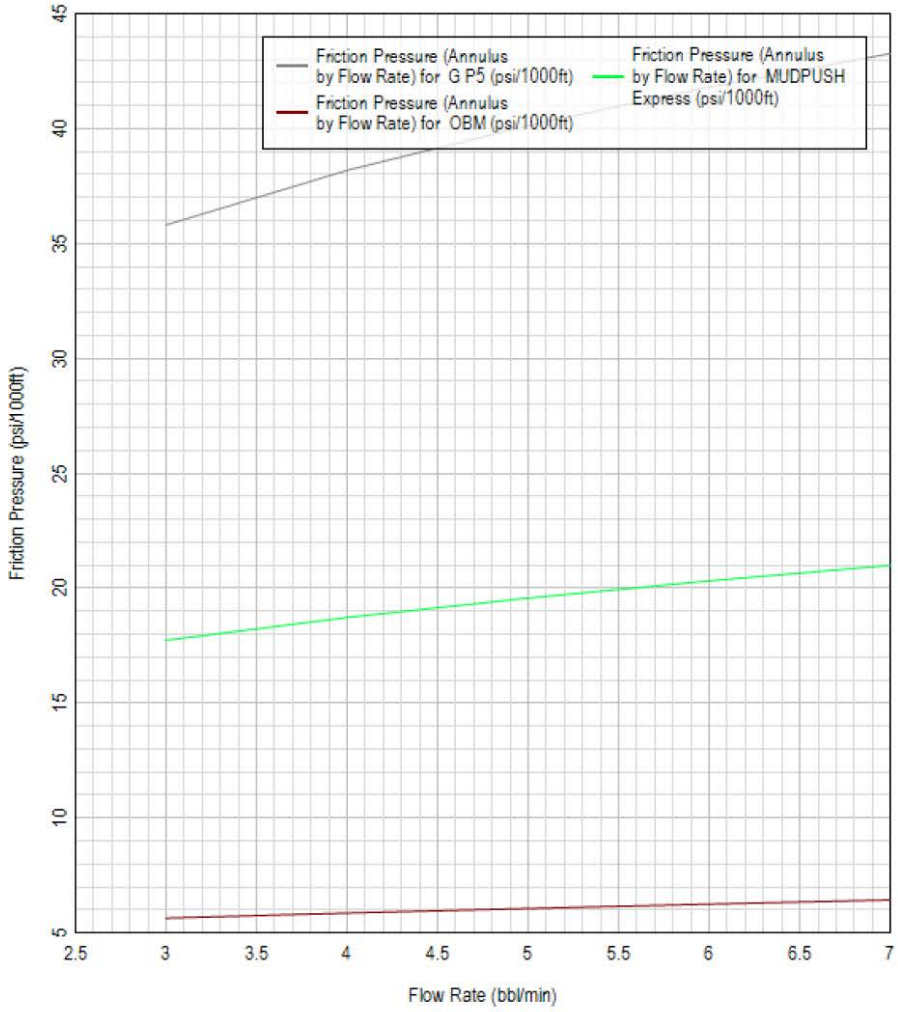
# Friction Pressure Calculator

Fluid rates are calculated at P = 15 psi and T = 68.0 degF

## Flow in Annulus at Various Rates

Pipe External Diameter: 5.000 in
Flow Rate – Minimum: 3.0 bbl/min

Hole Diameter: 8.750 in
Flow Rate – Maximum: 7.0 bbl/min






# Cypress M2
# Sundance-Dakota-JSand Plug
version 5 plug 7
1/22/2024

Rig : True Drilling 38

Prepared for:
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Tallgrass Energy
7202996780
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# Job Objectives and Design Considerations

## Job Objectives

Mud company to spot 117' viscous pill below 8311' prior cement operations to support plug.
Circ. to cool down well and condition mud as per schedule.
Cement balanced plug to abandon Sundance, Dakota, J Sand formations (8322-7641') from 8311-7561' (80' above J Sand and 61' below Sundance, 750' plug length) in 8 3/4" OH (5% excess over caliper), no plan of tagging (expected TOC ~7625'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (7261') @ 40'/min rotating pipe slow and circulate to clean out excess.

## Acceptance Criteria

Pump as per design

### Operational Risk Statement

Cement plugs operations are complex to design and execute and this complexity should not be underestimated. Cement plugs operations should never be considered as a “routine” job. To successfully set cement plugs the same methodology used to design and execute primary cement jobs is required, which includes but is not limited to correct slurry design, mud-removal and placement design based on accurate well data. Cement plugs are remedial cementing treatments. The first design step is the determination of the actual problem to solve, i.e. define the purpose of setting a cement plug. The second step consists in defining the evaluation criteria: tag / no tag, positive pressure test, negative test, etc. Both steps allow for the proper specification of slurry properties and the determination of the adequate plug placement technique. This can result in additional laboratory tests as well as additional equipment requirements.

Nelson in Well Cementing (2006) discusses several factors that are key to successful plug cementing operations.
Displacement and under-displacement volumes play a critical role for the success of the job. The volumes specified in this program should be followed.
Fluid contamination/mixing during plug setting can jeopardize job success. To mitigate this risk, using a stable base for the plug, mechanical separators, and appropriate wait-on-cement-time is strongly recommended.
In case of a Kick-off Plug, proper knowledge of the BHA and application of correct drilling techniques are required to kick-off.

In case of any deviation from the approved job procedure, a Management of Change (MoC) is required. By raising a MoC to the appropriate level within the operator organization as well as within SLB, all the operational risks can be identified and addressed prior to execution of the cement plug.

# Plug Operation Summary

Overview of the cementing operation (temperatures, fluid types, rates and general notes)
**All depths (except water depth) take the rig floor as reference**

## Well & Rig Information

| | |
|---|---|
| Rig Type: | Land |

Objective: Mud company to spot 117' viscous pill below 8311' prior cement operations to support plug.
Cement balanced plug to abandon Sundance, Dakota, J Sand formations (8322-7641') from 8311-7561' (80' above J Sand and 61' below Sundance, 750' plug length) in 8 3/4" OH (5% excess over caliper), no plan of tagging (expected TOC ~7625'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg G. Underdisplace 0bbl.
POOH 300' above theoretical TOC (7261') @ 40'/min rotating pipe slow and circulate to clean out excess.

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |
| Well Deviation: | 0.0 deg |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Placement & Post-Placement Conditions

| | |
|---|---|
| **Top:** | **7561.0 ft** |
| Length: | 750.0 ft |
| **Bottom:** | **8311.0 ft** |
| **Support:** | **VISCOUS PILL** |

| | |
|---|---|
| Mechanical Separator: | AHEAD AND BEHIND |
| Pipe Rotation / Reciprocation: | ROTATION |

| | |
|---|---|
| POOH Depth: | 7261.0 ft |
| POOH Speed: | 30-40FT/MIN |
| Circ. Rate: | 8.0 bbl/min |
| Circ. Direction: | Direct |

| | |
|---|---|
| String type and configuration: | OPEN ENDED |

## Design Considerations

| **G P7** | |
|---|---|
| Cement Type: | Slurry |
| Slurry Dens.: | 15.80 lb/gal |

| **MUDPUSH Express** | |
|---|---|
| Spacer Type: | Spacer |
| Spacer Dens.: | 12.00 lb/gal |

| **OBM** | |
|---|---|
| Mud Type: | Oil Based Mud |
| Mud Dens.: | 9.40 lb/gal |

| | | | |
|---|---|---|---|
| **Volume Balance Model:** | Optimize Slurry & Spacer | Underdispl.: | 0.0 bbl |

## Pumping Schedule

| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Comment | Inj. Temp. degF |
|---|---|---|---|---|---|
| Pause | | | 00:00 | Circ to cool down well and cond mud 120min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.6 | 5.0 | 00:04 | | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| G P7 | 56.9 | 5.0 | 00:11 | MinTT 4:08 | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| MUDPUSH Express | 6.4 | 5.0 | 00:01 | | 80.0 |
| OBM | 126.7 | 5.0 | 00:25 | | 80.0 |



| | | | | | |
|---|---|---|---|---|---|
| Pause | | | 00:10 | Break cmt. lines | |
| Pause | | | 00:26 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:48 | Rig circ. pipe clean excess 385bbl @ 8bpm | |
| Pause | | | 00:00 | | |
| Shut-in | | | 00:00 | | |

| Temperature Simulation | | | | |
|---|---|---|---|---|
| Pre-job Circ. Rate: | 8 bbl/min | | BHST: | 210.1 degF |
| Pre-job Circ. Time: | 120 MIN | | Simulated BHCT: | 159.0 degF |

# Well Data Summary

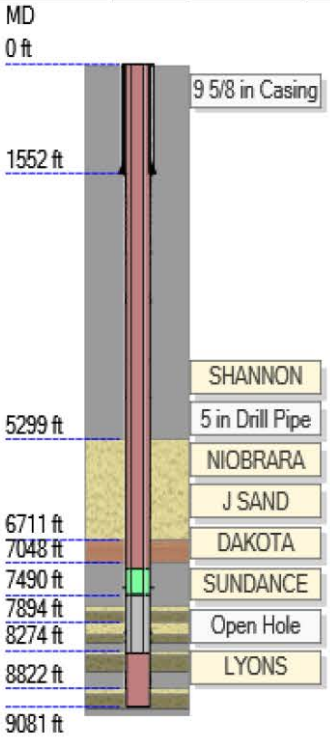
The cementing program incorporates the following data:
**All depths (except water depth) take the rig floor as reference**

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Tubulars and Casing Hardware

| | MD ft | OD in | Weight lb/ft | Grade | ID in | Thread | Collapse psi | Burst psi | Joint ft |
|---|---|---|---|---|---|---|---|---|---|
| Prev Casing | 1551.5 | 9 5/8 | 40.0 | J-55 | 8.835 | | 2570 | 3950 | 1.0 |
| Workstring | 8311.0 | 5 | 19.5 | E75 | 4.276 | | 10000 | 9500 | 40.0 |



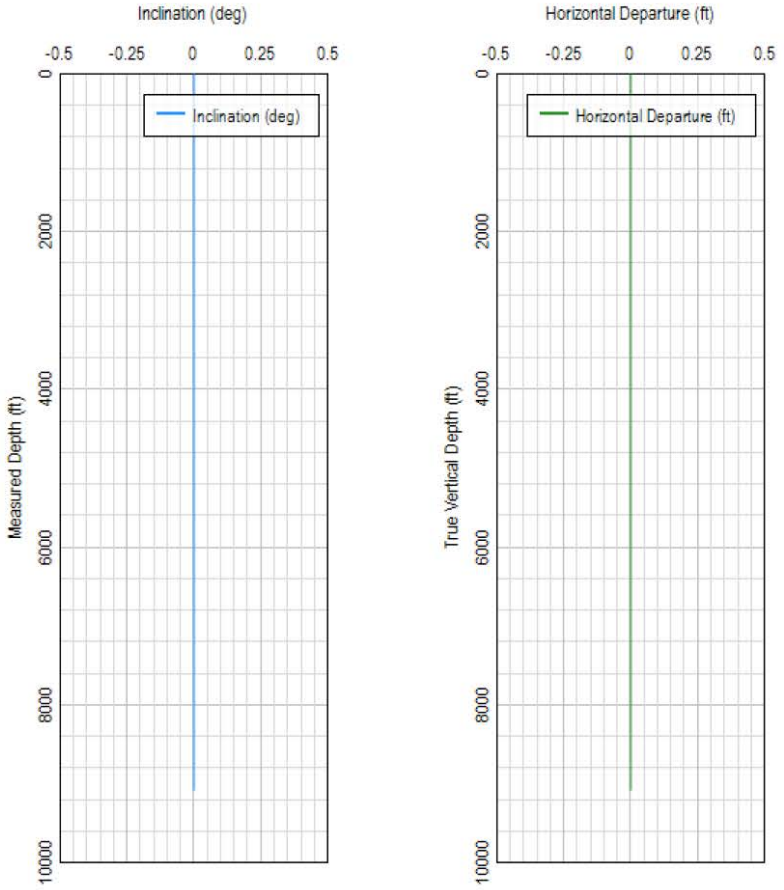

## Open Hole

| | |
|---|---|
| Total OH Volume: | 576.9 bbl |
| Minimum Diameter: | 8.473 in |
| Maximum Diameter: | 12.776 in |

| | |
|---|---|
| Mean Diameter: | 8.750 in |
| Mean Ann. Excess: | 5.000 % |
| Mean Eq. Diameter: | 8.881 in |

Note : OH caliper was uploaded.

## Directional Survey



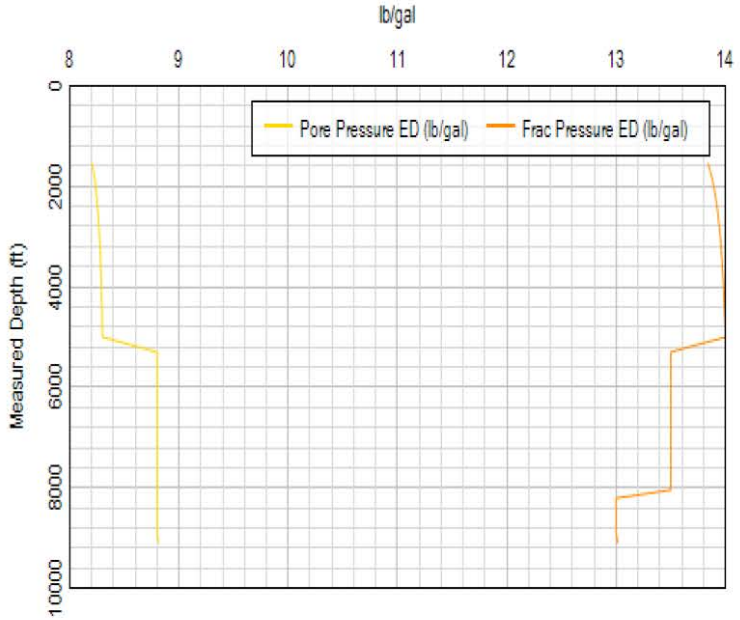

**Note:** Hole assumed vertical

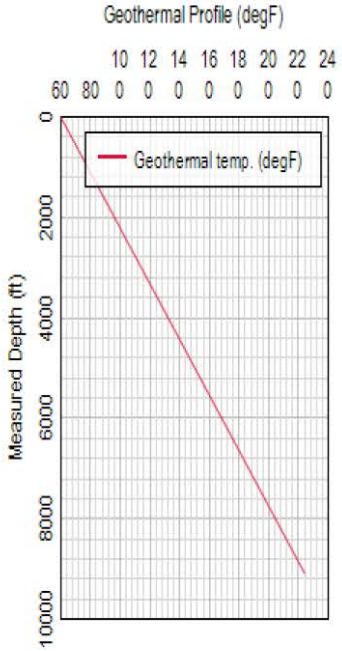
## Formation

| Top MD ft | Bottom MD ft | Bottom TVD ft | Frac Top ED lb/gal | Frac Bottom ED lb/gal | Pore Top ED lb/gal | Pore Bottom ED lb/gal | Lithology | Res. Fluid | Name |
|---|---|---|---|---|---|---|---|---|---|
| 25.5 | 5000.0 | 5000.0 | 0.00 | 14.00 | 0.00 | 8.30 | | | |
| 5000.0 | 5299.0 | 5299.0 | 14.00 | 13.50 | 8.30 | 8.80 | | | |
| 5299.0 | 6711.0 | 6711.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | SHANNON |
| 6711.0 | 7048.0 | 7048.0 | 13.50 | 13.50 | 8.80 | 8.80 | Shale | | NIOBRARA |
| 7048.0 | 7250.0 | 7250.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7250.0 | 7655.0 | 7655.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7655.0 | 7734.0 | 7734.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | J SAND |
| 7734.0 | 7894.0 | 7894.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7894.0 | 8042.0 | 8042.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | DAKOTA |
| 8042.0 | 8200.0 | 8200.0 | 13.50 | 13.00 | 8.80 | 8.80 | | | |
| 8200.0 | 8274.0 | 8274.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8274.0 | 8336.0 | 8336.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | SUNDANCE |
| 8336.0 | 8500.0 | 8500.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8500.0 | 8600.0 | 8600.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8600.0 | 8682.0 | 8682.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8682.0 | 8822.0 | 8822.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8822.0 | 8891.0 | 8891.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | LYONS |
| 8891.0 | 9081.0 | 9081.0 | 13.00 | 13.01 | 8.80 | 8.81 | | | |

| Temperature | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Top MD ft | Bottom MD ft | Bottom TVD ft | Temp. degF | Temp. Gradient degF/100ft | Temp. Rel. Gradient degF/100ft | |
| Surface | 0.0 | 0.0 | 0.0 | 60.0 | 0.00 | | |
| BHST | 0.0 | 8311.0 | 8311.0 | 210.1 | 1.81 | 1.81 | |
| Rock | 8311.0 | 9081.0 | 9081.0 | 224.0 | 1.81 | 1.81 | |

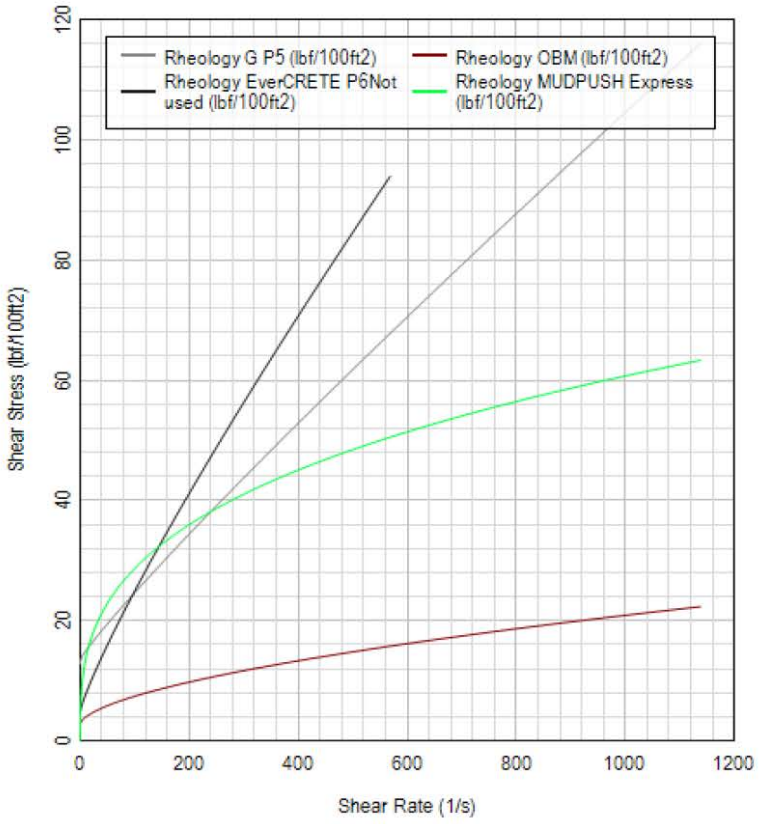
**Source of temperature data:** 224degF at BH from 3 different SLB WL Logs, confirmed with client



# Fluids Summary

| Fluids | | | | | | |
|---|---|---|---|---|---|---|
| Type | Name | Density lb/gal | Conditions | K lbf.s^n/ft2 | n | Ty lbf/100ft2 |
| Drilling Fluid | OBM | 9.40 | Downhole 190.0 degF | 3.03E-3 | 0.589 | 2.59 |
| Spacer | MUDPUSH Express | 12.00 | Downhole 190.0 degF WCO 2023-153 | 6.15E-2 | 0.325 | 0.00 |
| Slurry | G P7 | 15.80 | Downhole 180.0 degF | 1.60E-3 | 0.918 | 12.80 |




| Fluid Density and Rheology Tolerance |
|---|
| **Mud** – properties to be verified prior to job with mud engineer, contact engineer onshore if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg rheology difference from planned : +/- 10% |
| **Spacer** – properties to be verified prior to job, see contingency plans if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg |
| **Slurry** – cement slurry should be mixed within the range described below, see contingency plans if there is mismatch between designed density and slurry volume<br>density difference from planned : +/- 0.2 ppg |

# Mud Circulation

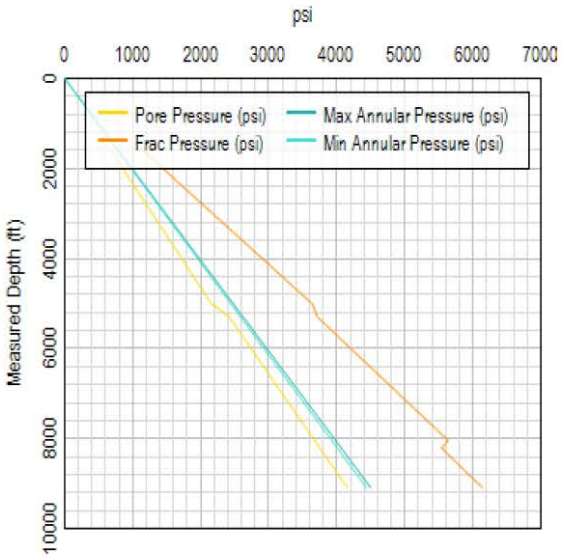
| | |
|---|---|
| Fluid | OBM |
| Number of Circulations | 1.646 |
| Total Volume at Ambient Temperature | 960.0 bbl |
| Ambient Temperature | 80.0 degF |
| Correction Slope | 0.700 |

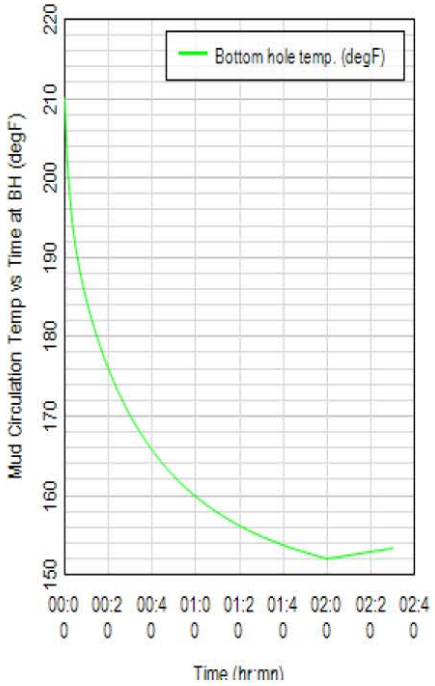
**Pumping Stages**

| Fluid | Pump Rate bbl/min | Duration hr:mn | Volume bbl |
|---|---|---|---|
| OBM | 8.0 | 02:00 | 960.0 |
| Pause | | 00:30 | |

**Well Security**

| Status | Description | Min Differential Pressure psi | At Depth ft | At Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 346 | 1551.5 | 02:00 |
| Success | Production/Influx | 96 | 1551.5 | 02:30 |
| Success | Burst | 9244 | 0.0 | 00:00 |
| Success | Collapse | 9412 | 8311.0 | 02:30 |



# Fluid Placement

## Volume Balance Objectives

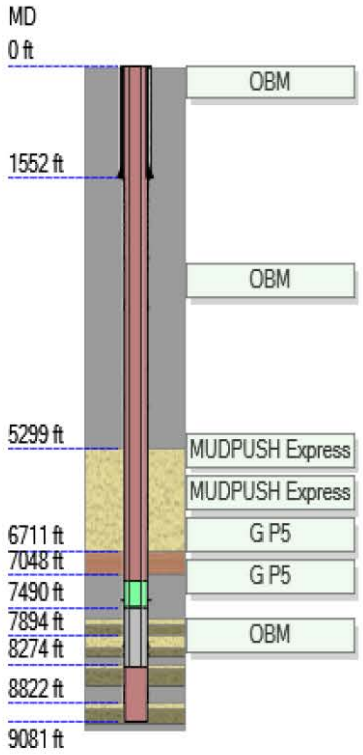
Volume Balance Model: **Optimize Slurry & Spacer**

| | | | | | |
|---|---|---|---|---|---|
| Original Fluid: | OBM | Rat Hole Fluid: | OBM | Displ. Fluid: | OBM |
| Top Spacer: | MUDPUSH Express | set Total Volume to: | 25.0 bbl | | |
| Top Slurry: | G P7 | set Top MD to: | 7561.0 ft | | |

Annulus is **not** filled during POOH.

## Volume Balance Results

| | | | | | |
|---|---|---|---|---|---|
| String Volume: | 147.6 bbl | Underdispl.: | 0.0 bbl | Displ. Volume: | 126.7 bbl |
| TOC after POOH: | 7561.0 ft | Cement Length after POOH: | 750.0 ft | | |




## Fluid Placement in Annulus

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.0 | 7128.9 | 7128.9 | 374.7 | 9.40 |
| MUDPUSH Express | 7128.9 | 7491.7 | 362.7 | 18.6 | 12.00 |
| G P7 | 7491.7 | 8311.0 | 819.3 | 42.3 | 15.80 |

## Fluid Placement in Pipe

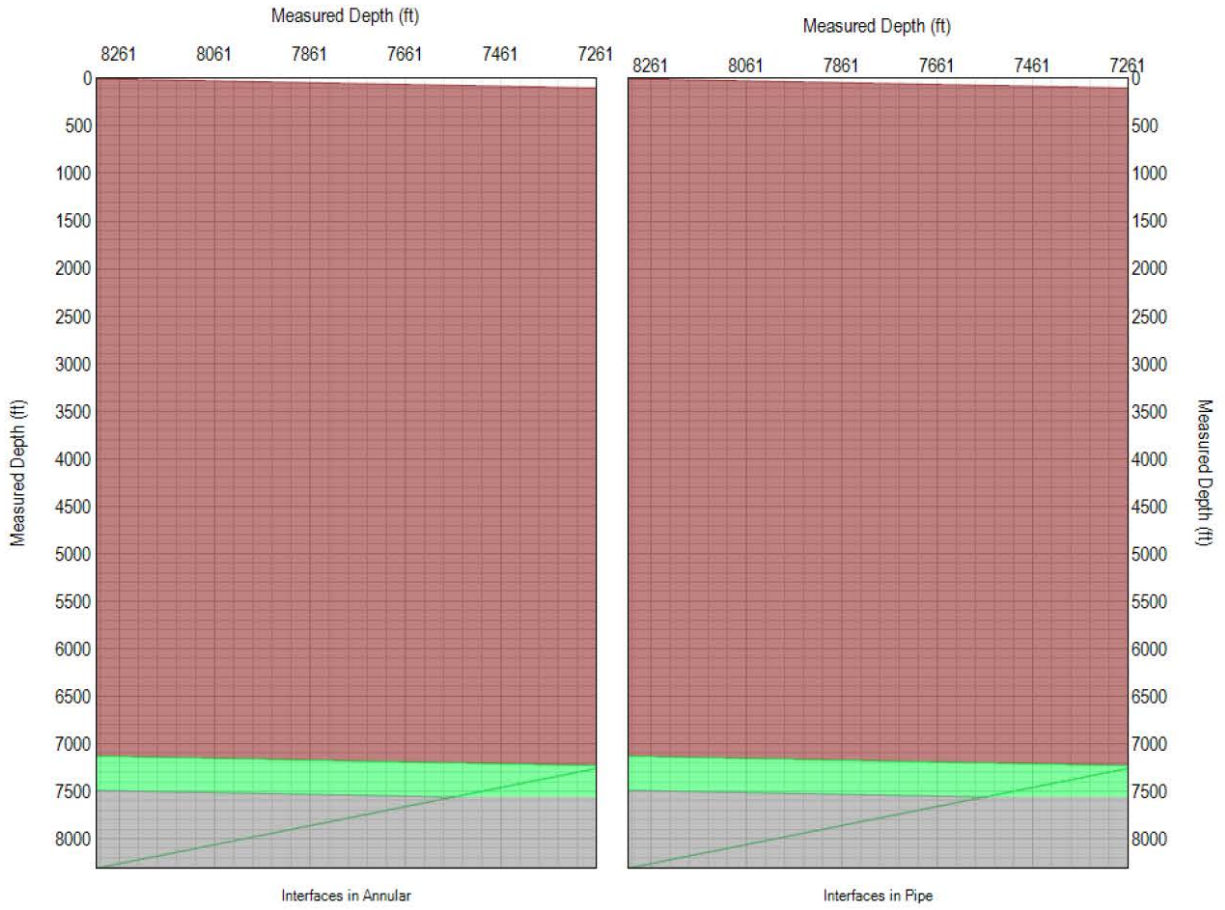
| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.0 | 7130.8 | 7130.8 | 126.7 | 9.40 |
| MUDPUSH Express | 7130.8 | 7490.4 | 359.7 | 6.4 | 12.00 |
| G P7 | 7490.4 | 8311.0 | 820.6 | 14.6 | 15.80 |

Note: Surface densities of compressible fluids are calculated at surface conditions, ie. **P = 1 atm** and **T = 60.0 degF**

# Static Pull Out Of Hole (POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP Depth: | 7261.0 ft | | Theoretical Top of Plug: | 7561.0 ft |
| POOH Length: | 1050.0 ft | | Theoretical Plug Length: | 750.0 ft |
| POOH Speed: | 30-40ft/min | | Plug Bottom: | 8311.0 ft |
| **Top of uncontaminated cement after POOH:** | | | | **7561.0 ft** |
| **Uncontaminated cement length after POOH:** | | | | **750.0 ft** |
| Contaminated cement length after POOH: | | | | 0.0 ft |

## POOH Results Summary




Note: Simulation assumes that fluids are free to balance themselves.

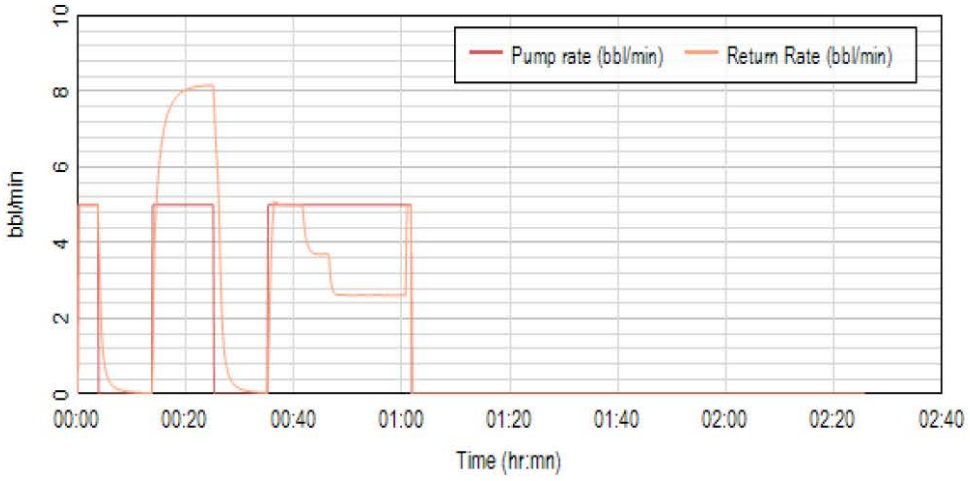
# Pumping Schedule

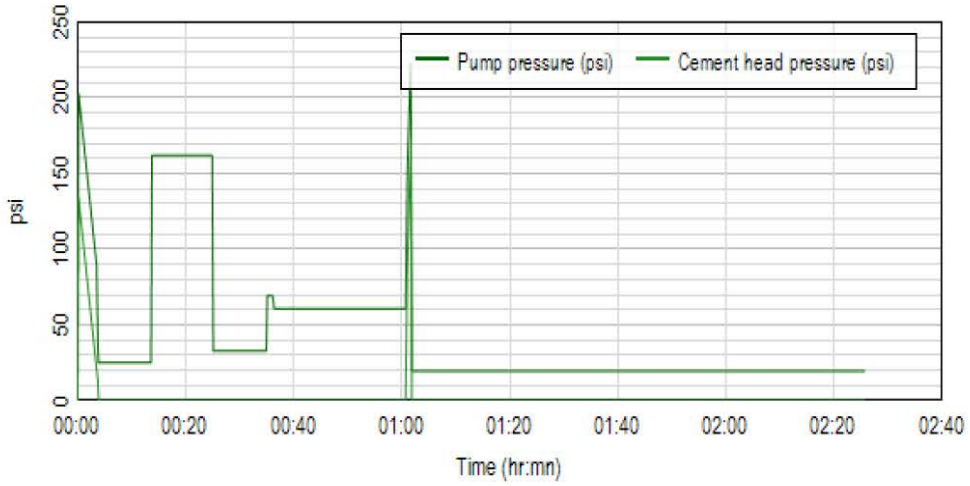
| Pumping Schedule | | | | | | |
|---|---|---|---|---|---|---|
| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Cum. Time hr:mn | Comment | Inj. Temp. degF |
| Pause | | | 00:00 | 00:00 | Circ to cool down well and cond mud 120min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 18.6 | 5.0 | 00:04 | 00:04 | | 80.0 |
| Plug | | | 00:10 | 00:14 | Foam ball | |
| G P7 | 56.9 | 5.0 | 00:11 | 00:25 | MinTT 4:08 | 80.0 |
| Plug | | | 00:10 | 00:35 | Foam ball | |
| MUDPUSH Express | 6.4 | 5.0 | 00:01 | 00:36 | | 80.0 |
| OBM | 126.7 | 5.0 | 00:25 | 01:02 | | 80.0 |
| Pause | | | 00:10 | 01:12 | Break cmt. lines | |
| Pause | | | 00:26 | 01:38 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:48 | 02:26 | Rig circ. pipe clean excess 385bbl @ 8bpm | |
| Pause | | | 00:00 | 02:26 | | |
| Shut-in | | | 00:00 | 02:26 | | |

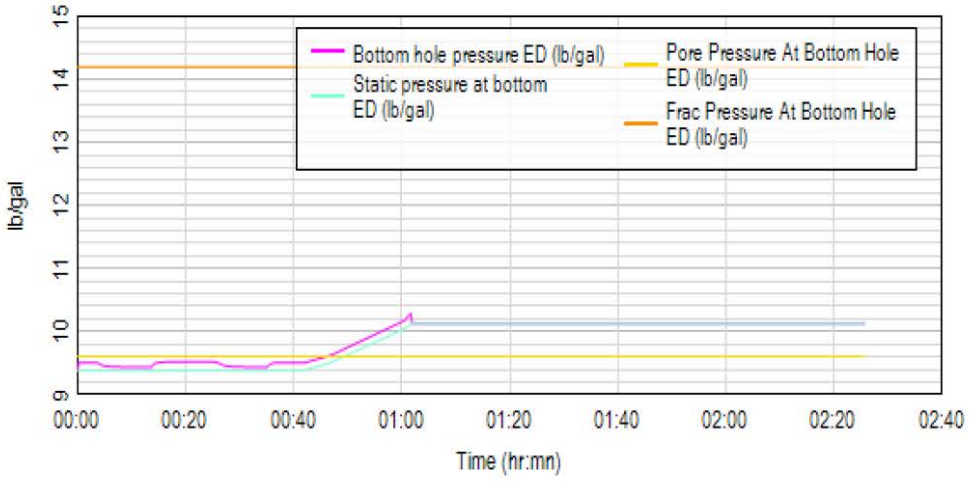
| | |
|---|---|
| Maximum Required Hydraulic Horsepower (HHP) | 27.3 hhp (at 01:02 hr:mn) |

| Displacement Volume Considerations | | |
|---|---|---|
| | Volume bbl | Variation bbl |
| Theoretical displacement volume | 126.7 | |
| Underdisplacement | | 0.0 |
| Final Displacement | 126.7 | |

Pauses in the jobs are only estimates – all efforts should be made during the operation to minimize these times.



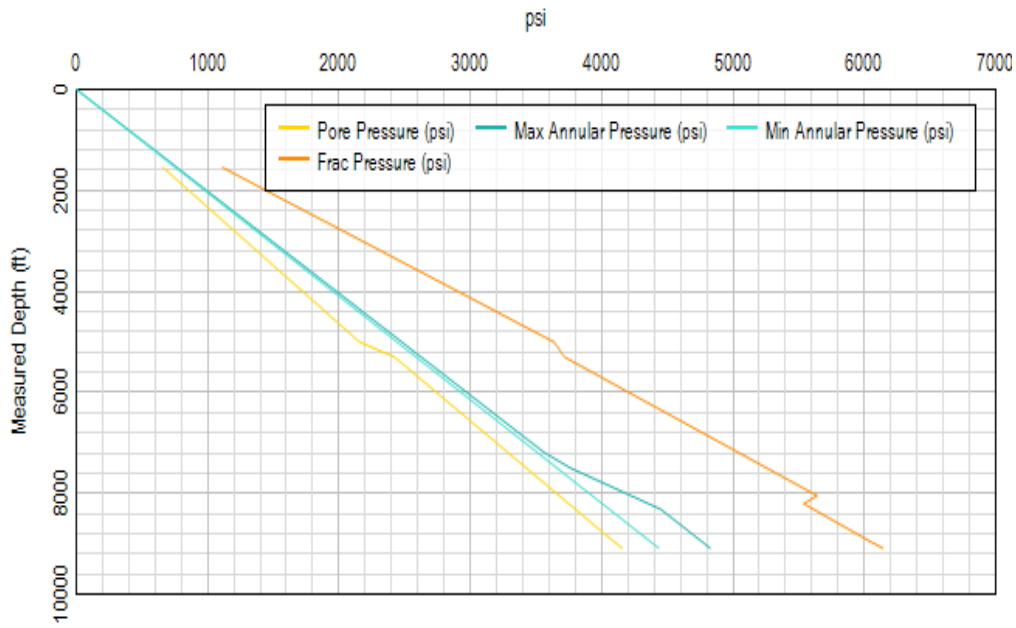

Pump pressure (psi)
Cement head pressure (psi)
psi
0
50
100
150
200
250
00:00
00:20
00:40
01:00
01:20
01:40
02:00
02:20
02:40
Time (hr:mn)


Bottom hole pressure ED (lb/gal)
Static pressure at bottom ED (lb/gal)
Pore Pressure At Bottom Hole ED (lb/gal)
Frac Pressure At Bottom Hole ED (lb/gal)
lb/gal
9
10
11
12
13
14
15
00:00
00:20
00:40
01:00
01:20
01:40
02:00
02:20
02:40
Time (hr:mn)

# Well Security

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 346 | 1551.5 | 00:25 |
| Success | Production/Influx | 96 | 1551.5 | 02:26 |
| Success | Burst | 9327 | 0.0 | 01:02 |
| Success | Collapse | 8671 | 3773.0 | 00:41 |

## Well Control



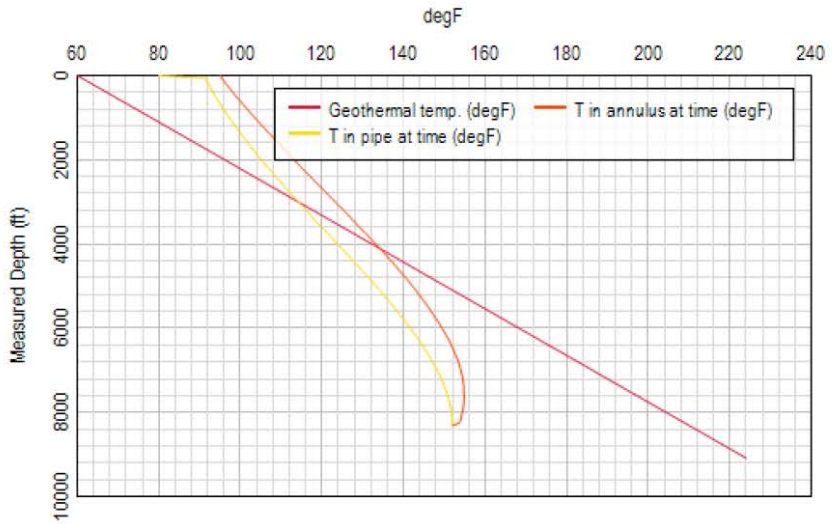
# Temperature Outputs

| | |
|---|---|
| BHST: | 210.1 degF |
| Static Temp at TOC: | 195.3 degF |

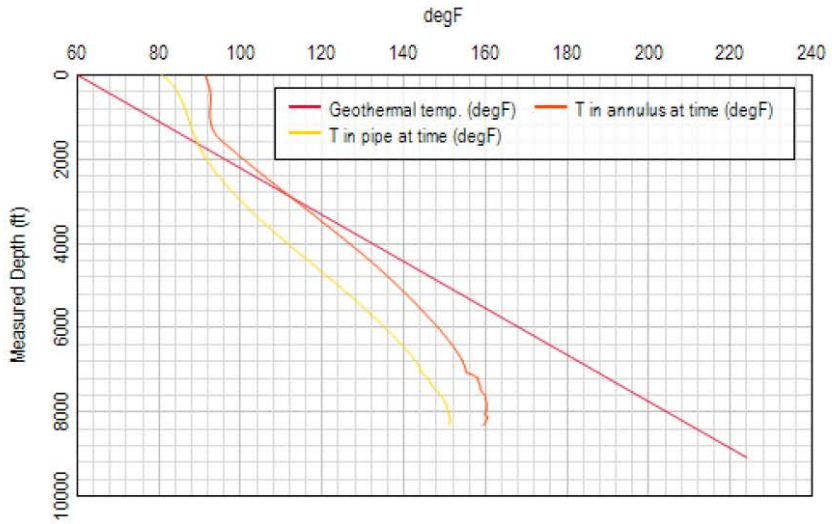
| | |
|---|---|
| Simulated BHCT: | 159.0 degF |
| Simulated HCT at TOC: | 158.9 degF |

Temperature simulation initial condition: Mud Circulation profile

## Initial Condition

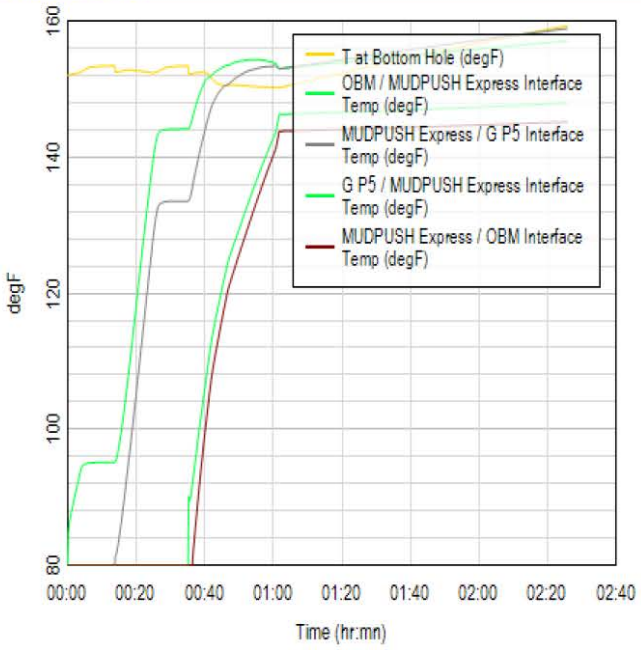



## Final Condition

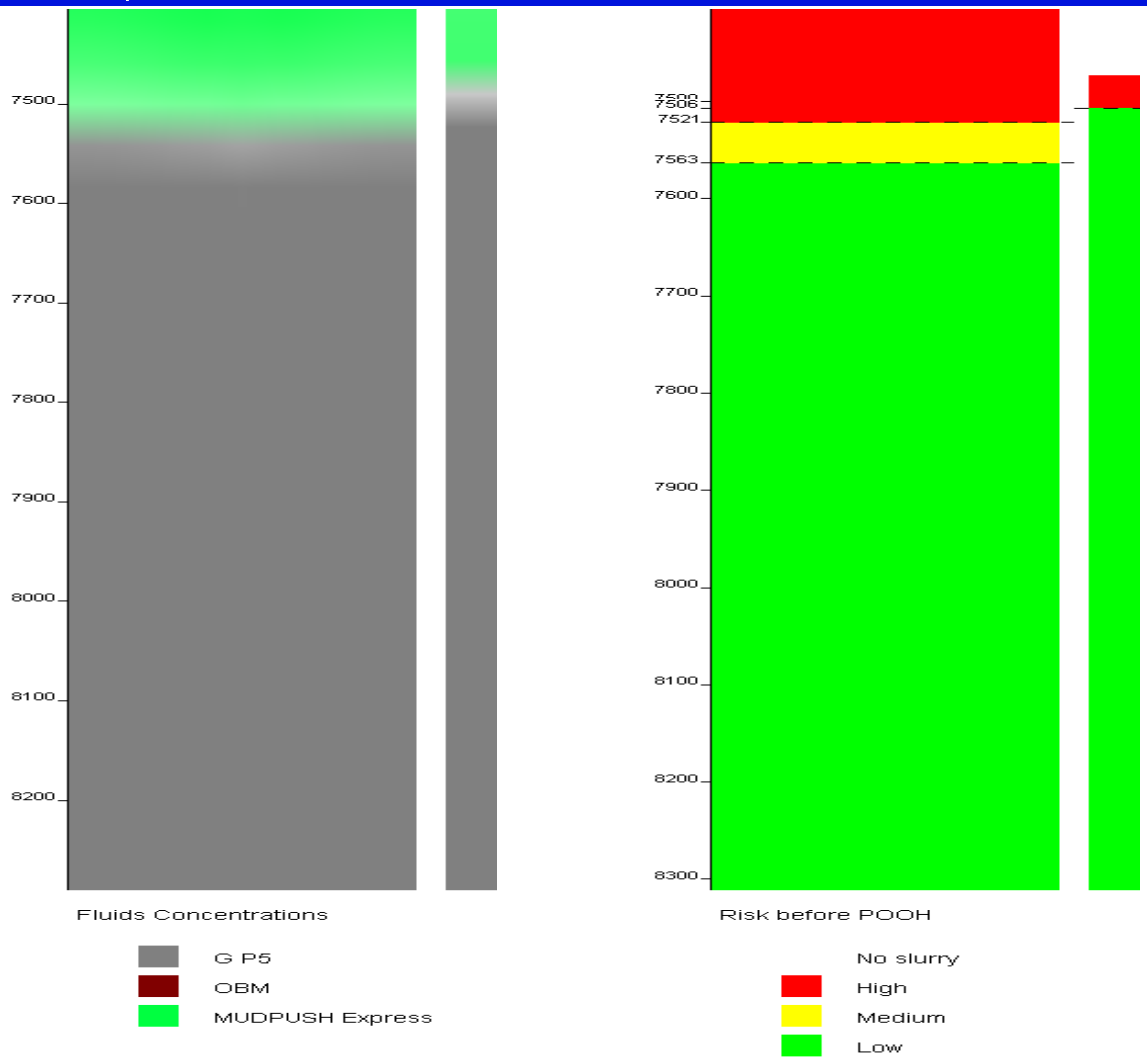



t = 02:26 hr:mn

## BHCT and Interface Temperatures



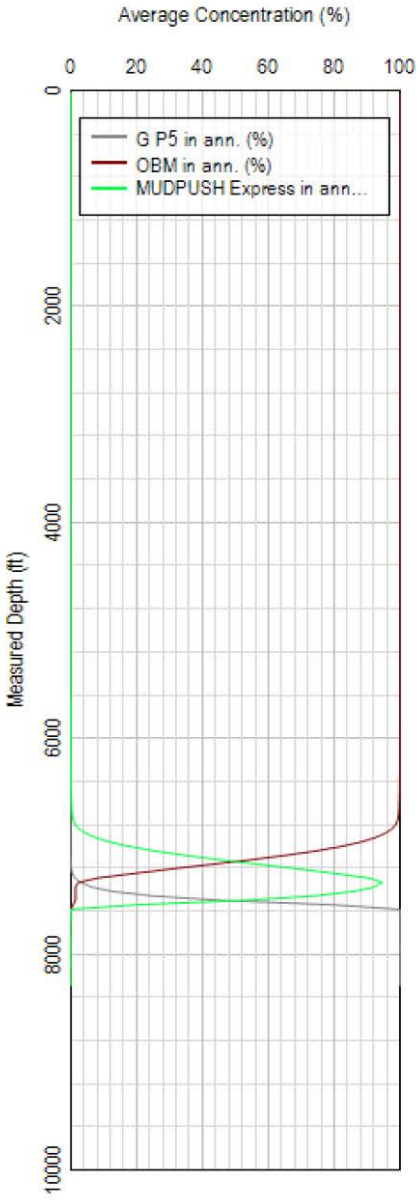
## WELLCLEAN III Maps



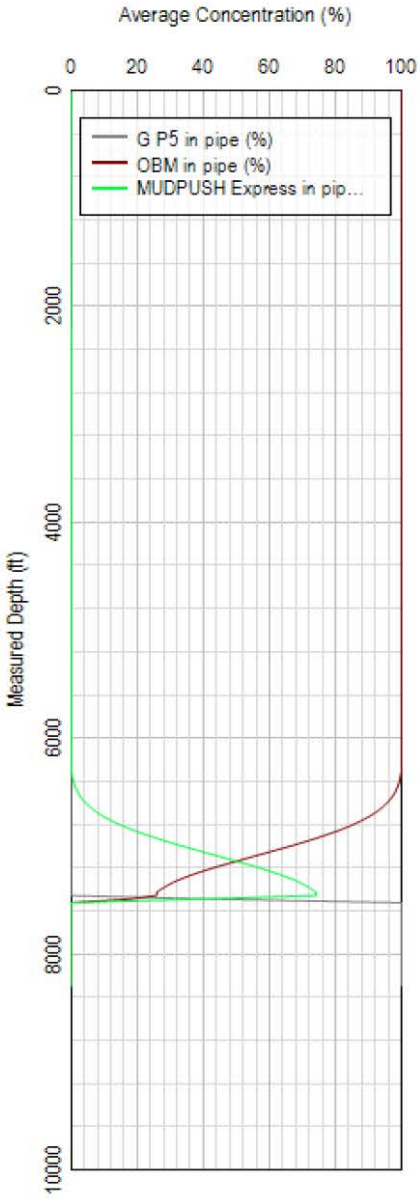

| | |
|---|---|
| **No cement slurry** | Slurry concentration is less than 10% (by unit of volume).<br>The concentration is below minimum threshold to consider that cement is present. |
| **High risk of contamination** | Slurry concentration is between 10% and 50% (by unit of volume).<br>There is no chance of finding hard cement when tagging within a few hours. |
| **Medium risk of contamination** | Slurry concentration is between 50% and 90% (by unit of volume).<br>It is possible to find some soft cement when tagging but it will most likely not be strong enough to kick off the well or even to provide a proper wellbore isolation. |
| **Low risk of contamination** | Slurry concentration is between 90% and 100% (by unit of volume).<br>Cement plug should be designed in such a way that the target of the top of cement should be within the 'green risk' zone. Hard cement should be found in that zone once compressive strength has developed, i.e. after the duration determined by the lab tests at downhole condition. |

## Fluid Concentrations before POOH

Average fluid concentration in annulus



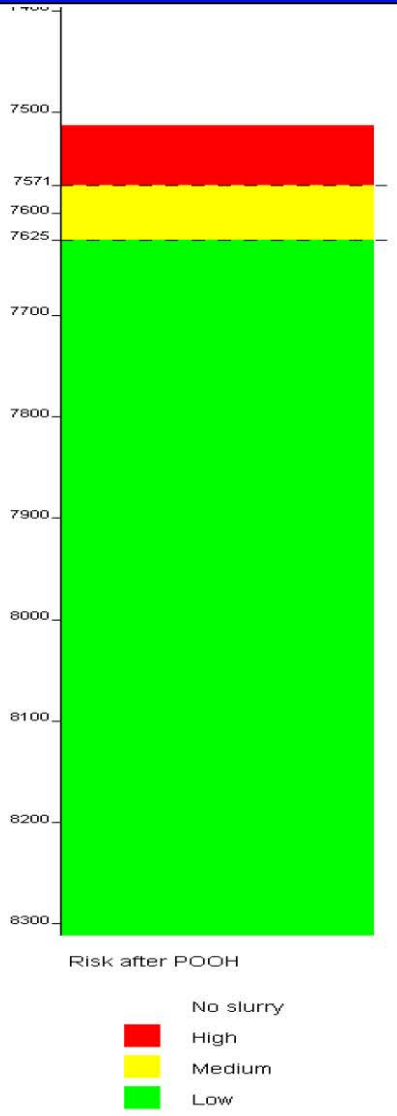

Average fluid concentration in pipe



# Final Contamination Risk (After POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP depth: | 7261.0 ft | | Theoretical Top of Plug: | 7561.0 ft |
| Theoretical Top of Plug (based on slurry volume) | | | | 7561.0 ft |
| Estimated TOC based on uncontaminated POOH simulation | | | | 7561.0 ft |
| Estimated TOC after POOH considering contamination during placement | | | | 7625.8 ft |

## Final Contamination Risk




Note: Simulation assumes that fluids are free to balance themselves

# Post-placement Circulation

Volume of compressible fluids is displayed at ambient conditions, ie. P = 1 atm and T = 60.0 degF

| | | | |
|---|---|---|---|
| DP Depth for Circulation: | 7261.0 ft | Designed TOC: | 7561.0 ft |

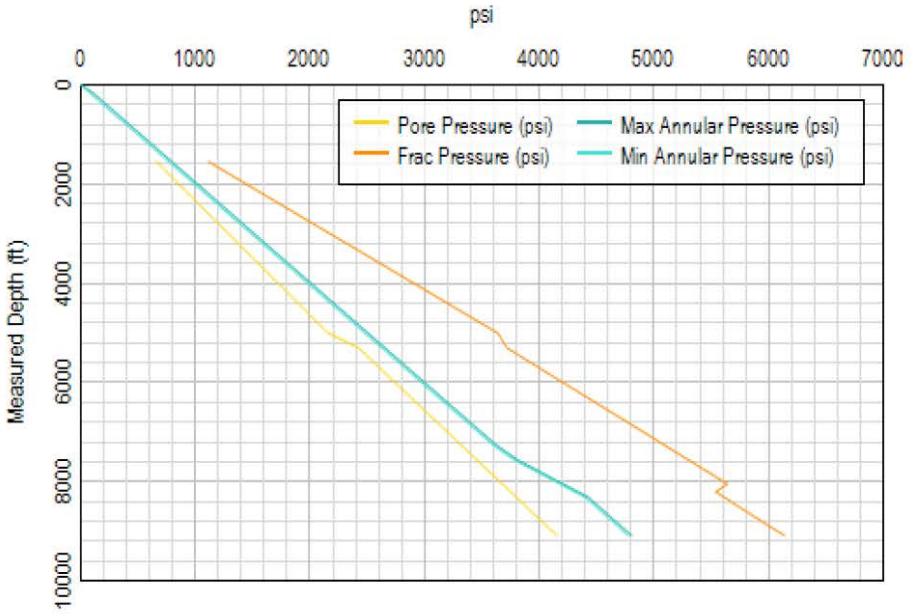
| | | | |
|---|---|---|---|
| Circulating Fluid: | OBM | Total Volume: | 384.0 bbl |
| Circulation Direction: | Direct | Number of Circulations: | 0.752 |

## Circulation Stages

| Stage | Pump Rate bbl/min | Duration hr:mn | Volume bbl | Back-pressure psi |
|---|---|---|---|---|
| OBM | 8.0 | 00:48 | 384.0 | 0 |

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 319 | 1551.5 | 00:47 |
| Success | Production/Influx | 108 | 1551.5 | 00:48 |
| Success | Burst | 9249 | 0.0 | 00:01 |
| Success | Collapse | 9484 | 7261.0 | 00:00 |

## Post-Placement Well Control






# Cypress M2
# Lyons Plug
version 5 plug 8
1/22/2024

Rig : True Drilling 38

Prepared for:
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# Job Objectives and Design Considerations

## Job Objectives

Mud company to spot 153' viscous pill below 8928' prior cement operations to support plug.
Circ. to cool down well and condition mud as per schedule.
Cement balanced plug to abandon Lyons formation (8809-8878') from 8928-8428' (381' above Lyons and 50' below, 500' plug length) to withstand tag in 8 3/4" OH (5% excess over caliper) to increase chances of tagging at desired depth above top of formation (tag ~8480'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg EverCRETE*. Underdisplace 0bbl.
POOH 300' above theoretical TOC (8128') @ 40'/min rotating pipe slow and circulate to clean out excess. WOC to reach at least 500psi CS @ TOC temp. before coming in to tag plug (~10,000lbf WOB) keeping low pump rate and rotate to avoid getting stuck on gelled mixture.

## Acceptance Criteria

Tag plug above Lyons formation.

### Operational Risk Statement

Cement plugs operations are complex to design and execute and this complexity should not be underestimated. Cement plugs operations should never be considered as a "routine" job. To successfully set cement plugs the same methodology used to design and execute primary cement jobs is required, which includes but is not limited to correct slurry design, mud-removal and placement design based on accurate well data. Cement plugs are remedial cementing treatments. The first design step is the determination of the actual problem to solve, i.e. define the purpose of setting a cement plug. The second step consists in defining the evaluation criteria: tag / no tag, positive pressure test, negative test, etc. Both steps allow for the proper specification of slurry properties and the determination of the adequate plug placement technique. This can result in additional laboratory tests as well as additional equipment requirements.

Nelson in Well Cementing (2006) discusses several factors that are key to successful plug cementing operations.
Displacement and under-displacement volumes play a critical role for the success of the job. The volumes specified in this program should be followed.
Fluid contamination/mixing during plug setting can jeopardize job success. To mitigate this risk, using a stable base for the plug, mechanical separators, and appropriate wait-on-cement-time is strongly recommended.
In case of a Kick-off Plug, proper knowledge of the BHA and application of correct drilling techniques are required to kick-off.

In case of any deviation from the approved job procedure, a Management of Change (MoC) is required. By raising a MoC to the appropriate level within the operator organization as well as within SLB, all the operational risks can be identified and addressed prior to execution of the cement plug.

# Plug Operation Summary

Overview of the cementing operation (temperatures, fluid types, rates and general notes)
**All depths (except water depth) take the rig floor as reference**

## Well & Rig Information

| | |
|---|---|
| Rig Type: | Land |

Objective: Mud company to spot 153' viscous pill below 8928' prior cement operations to support plug.
Circ. to cool down well and condition mud as per schedule.
Cement balanced plug to abandon Lyons formation (8809-8878') from 8928-8428' (381' above Lyons and 50' below, 500' plug length) to withstand tag in 8 3/4" OH (5% excess over caliper) to increase chances of tagging at desired depth above top of formation (tag ~8480'), using 5" open ended DP, 12ppg MUDPUSH*Express spacer, foam balls ahead and behind 15.8ppg EverCRETE*. Underdisplace 0bbl.
POOH 300' above theoretical TOC (8128') @ 40'/min rotating pipe slow and circulate to clean out excess. WOC to reach at least 500psi CS @ TOC temp. before coming in to tag plug (~10,000lbf WOB) keeping low pump rate and rotate to avoid getting stuck on gelled mixture.

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |
| Well Deviation: | 0.0 deg |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Placement & Post-Placement Conditions

| | |
|---|---|
| **Top:** | **8428.0 ft** |
| Length: | 500.0 ft |
| **Bottom:** | **8928.0 ft** |
| **Support:** | **VISCOUS PILL** |

| | |
|---|---|
| Mechanical Separator: | AHEAD AND BEHIND |
| Pipe Rotation / Reciprocation: | ROTATION |

| | |
|---|---|
| POOH Depth: | 8128.0 ft |
| POOH Speed: | 30-40FT/MIN |
| Circ. Rate: | 8.0 bbl/min |
| Circ. Direction: | Direct |

| | |
|---|---|
| String type and configuration: | OPEN ENDED |

## Design Considerations

| EverCRETE P8 | |
|---|---|
| Cement Type: | Slurry |
| Slurry Dens.: | 15.80 lb/gal |

| MUDPUSH Express | |
|---|---|
| Spacer Type: | Spacer |
| Spacer Dens.: | 12.00 lb/gal |

| OBM | |
|---|---|
| Mud Type: | Oil Based Mud |
| Mud Dens.: | 9.40 lb/gal |

| | |
|---|---|
| **Volume Balance Model:** | **Optimize Slurry & Spacer** |

| | |
|---|---|
| Underdispl.: | 0.0 bbl |

## Pumping Schedule

| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Comment | Inj. Temp. degF |
|---|---|---|---|---|---|
| Pause | | | 00:00 | Circ to cool down well and cond mud 120min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 28.2 | 5.0 | 00:06 | | 80.0 |
| Plug | | | 00:10 | Foam ball | |
| EverCRETE P8 | 38.6 | 5.0 | 00:08 | MinTT 4:10 | 80.0 |

| | | | | | |
|---|---|---|---|---|---|
| Plug | | | 00:10 | Foam ball | |
| MUDPUSH Express | 9.7 | 5.0 | 00:02 | | 80.0 |
| OBM | 139.1 | 5.0 | 00:28 | | 80.0 |
| Pause | | | 00:10 | Break cmt. lines | |
| Pause | | | 00:20 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:53 | Rig circ. pipe clean excess 425bbl @ 8bpm | |
| Pause | | | 00:00 | WOC to reach at least 500psi CS @ TOC temp. before coming in to tag plug (~10,000lbf WOB), keeping low pump rate and rotate to avoid getting stuck on gelled mixture | |
| Shut-in | | | 00:00 | | |

| Temperature Simulation | | | | |
|---|---|---|---|---|
| Pre-job Circ. Rate: | 8 bbl/min | | BHST: | 221.2 degF |
| Pre-job Circ. Time: | 120 MIN | | Simulated BHCT: | 173.1 degF |

# Well Data Summary

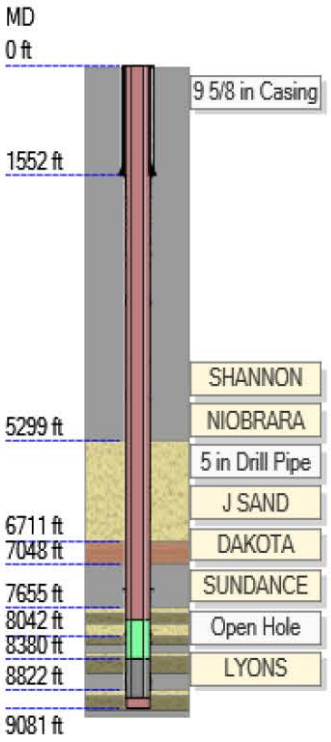
The cementing program incorporates the following data:
**All depths (except water depth) take the rig floor as reference**

| | |
|---|---|
| Section MD: | 9081.0 ft |
| Section TVD: | 9081.0 ft |

| | |
|---|---|
| Rig Floor Elev: | 25.5 ft |
| Mud Returns Depth: | 0.0 ft |

## Tubulars and Casing Hardware

| | MD ft | OD in | Weight lb/ft | Grade | ID in | Thread | Collapse psi | Burst psi | Joint ft |
|---|---|---|---|---|---|---|---|---|---|
| Prev Casing | 1551.5 | 9 5/8 | 40.0 | J-55 | 8.835 | | 2570 | 3950 | 1.0 |
| Workstring | 8928.0 | 5 | 19.5 | E75 | 4.276 | | 10000 | 9500 | 40.0 |



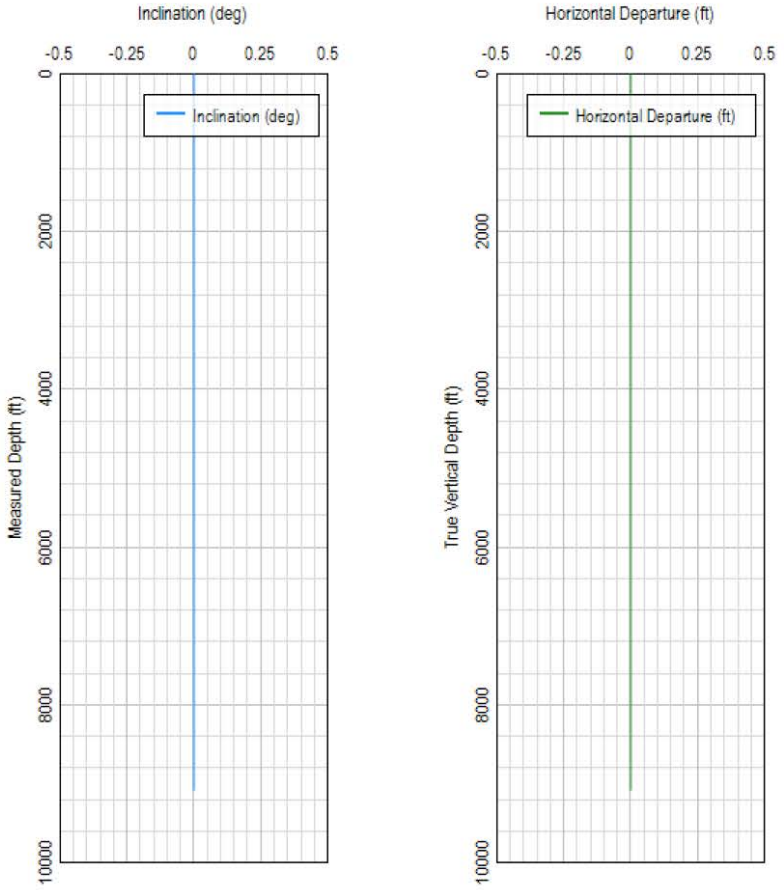

## Open Hole

| | |
|---|---|
| Total OH Volume: | 578.5 bbl |
| Minimum Diameter: | 8.473 in |
| Maximum Diameter: | 12.776 in |

| | |
|---|---|
| Mean Diameter: | 8.750 in |
| Mean Ann. Excess: | 5.000 % |
| Mean Eq. Diameter: | 8.893 in |

Note : OH caliper was uploaded.

## Directional Survey



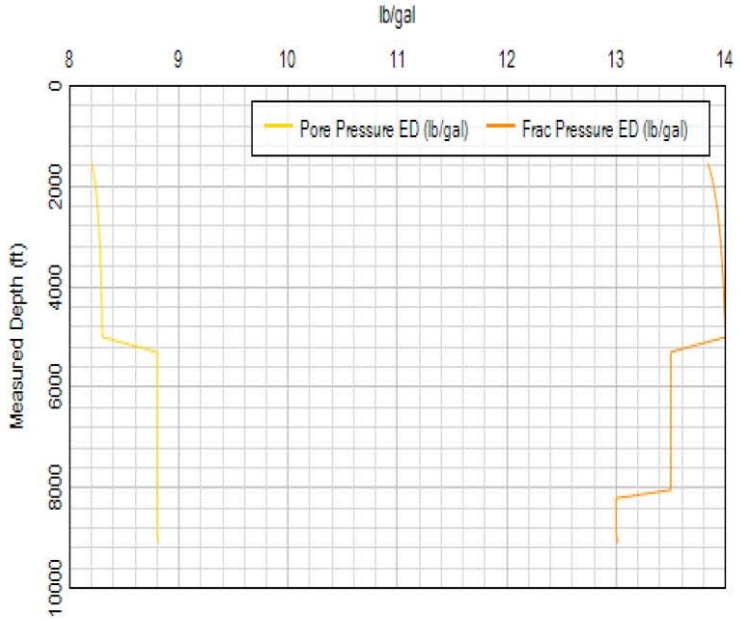

**Note:** Hole assumed vertical

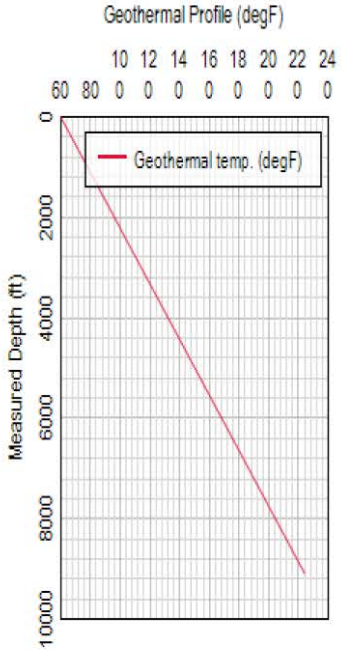
## Formation

| Top MD ft | Bottom MD ft | Bottom TVD ft | Frac Top ED lb/gal | Frac Bottom ED lb/gal | Pore Top ED lb/gal | Pore Bottom ED lb/gal | Lithology | Res. Fluid | Name |
|---|---|---|---|---|---|---|---|---|---|
| 25.5 | 5000.0 | 5000.0 | 0.00 | 14.00 | 0.00 | 8.30 | | | |
| 5000.0 | 5299.0 | 5299.0 | 14.00 | 13.50 | 8.30 | 8.80 | | | |
| 5299.0 | 6711.0 | 6711.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | SHANNON |
| 6711.0 | 7048.0 | 7048.0 | 13.50 | 13.50 | 8.80 | 8.80 | Shale | | NIOBRARA |
| 7048.0 | 7250.0 | 7250.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7250.0 | 7655.0 | 7655.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7655.0 | 7734.0 | 7734.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | J SAND |
| 7734.0 | 7894.0 | 7894.0 | 13.50 | 13.50 | 8.80 | 8.80 | | | |
| 7894.0 | 8042.0 | 8042.0 | 13.50 | 13.50 | 8.80 | 8.80 | Sandstone | | DAKOTA |
| 8042.0 | 8200.0 | 8200.0 | 13.50 | 13.00 | 8.80 | 8.80 | | | |
| 8200.0 | 8274.0 | 8274.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8274.0 | 8336.0 | 8336.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | SUNDANCE |
| 8336.0 | 8500.0 | 8500.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8500.0 | 8600.0 | 8600.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8600.0 | 8682.0 | 8682.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8682.0 | 8822.0 | 8822.0 | 13.00 | 13.00 | 8.80 | 8.80 | | | |
| 8822.0 | 8891.0 | 8891.0 | 13.00 | 13.00 | 8.80 | 8.80 | Sandstone | | LYONS |
| 8891.0 | 9081.0 | 9081.0 | 13.00 | 13.01 | 8.80 | 8.81 | | | |

| Temperature | | | | | | | |
|---|---|---|---|---|---|---|---|
| Name | Top MD ft | Bottom MD ft | Bottom TVD ft | Temp. degF | Temp. Gradient degF/100ft | Temp. Rel. Gradient degF/100ft | |
| Surface | 0.0 | 0.0 | 0.0 | 60.0 | 0.00 | | |
| BHST | 0.0 | 8928.0 | 8928.0 | 221.2 | 1.81 | 1.81 | |
| Rock | 8928.0 | 9081.0 | 9081.0 | 224.0 | 1.81 | 1.81 | |

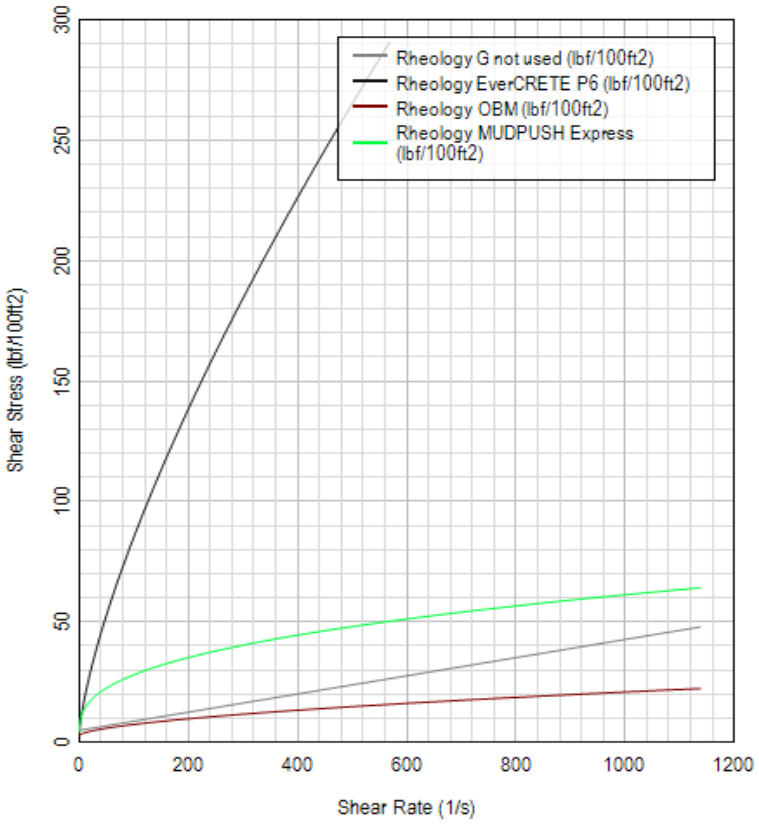
**Source of temperature data:** 224degF at BH from 3 different SLB WL Logs, confirmed with client



# Fluids Summary

| Fluids | | | | | | |
|---|---|---|---|---|---|---|
| Type | Name | Density lb/gal | Conditions | K lbf.s^n/ft2 | n | Ty lbf/100ft2 |
| Drilling Fluid | OBM | 9.40 | Downhole 190.0 degF | 3.03E-3 | 0.589 | 2.59 |
| Spacer | MUDPUSH Express | 12.00 | Downhole 190.0 degF wco2023153 | 3.94E-2 | 0.381 | 4.10 |
| Slurry | EverCRETE P8 | 15.80 | Downhole 184.0 degF wco2023153 | 2.85E-2 | 0.721 | 2.84 |




| Fluid Density and Rheology Tolerance |
|---|
| **Mud** – properties to be verified prior to job with mud engineer, contact engineer onshore if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg rheology difference from planned : +/- 10% |
| **Spacer** – properties to be verified prior to job, see contingency plans if deviation is outside the range below<br>density difference from planned : +/- 0.2 ppg |
| **Slurry** – cement slurry should be mixed within the range described below, see contingency plans if there is mismatch between designed density and slurry volume<br>density difference from planned : +/- 0.2 ppg |

# Mud Circulation

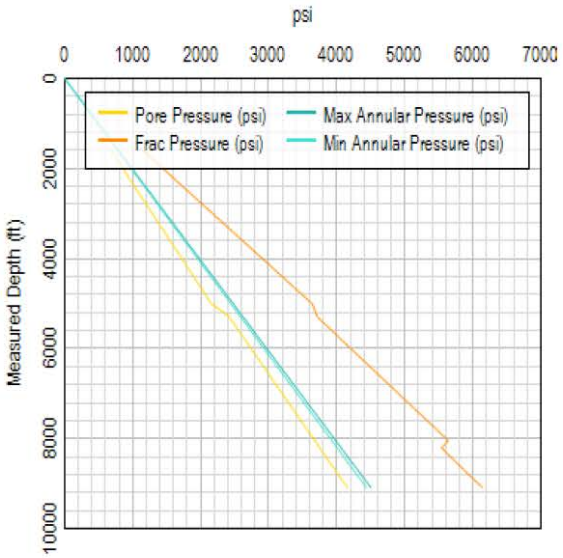
| | |
|---|---|
| Fluid | OBM |
| Number of Circulations | 1.532 |
| Total Volume at Ambient Temperature | 960.0 bbl |
| Ambient Temperature | 80.0 degF |
| Correction Slope | 0.700 |

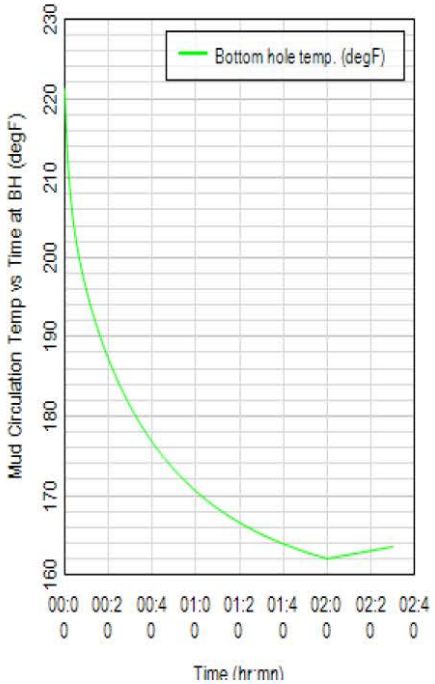
**Pumping Stages**

| Fluid | Pump Rate bbl/min | Duration hr:mn | Volume bbl |
|---|---|---|---|
| OBM | 8.0 | 02:00 | 960.0 |
| Pause | | 00:30 | |

**Well Security**

| Status | Description | Min Differential Pressure psi | At Depth ft | At Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 346 | 1551.5 | 02:00 |
| Success | Production/Influx | 96 | 1551.5 | 02:30 |
| Success | Burst | 9225 | 0.0 | 00:00 |
| Success | Collapse | 9369 | 8928.0 | 02:30 |



# Fluid Placement

## Volume Balance Objectives

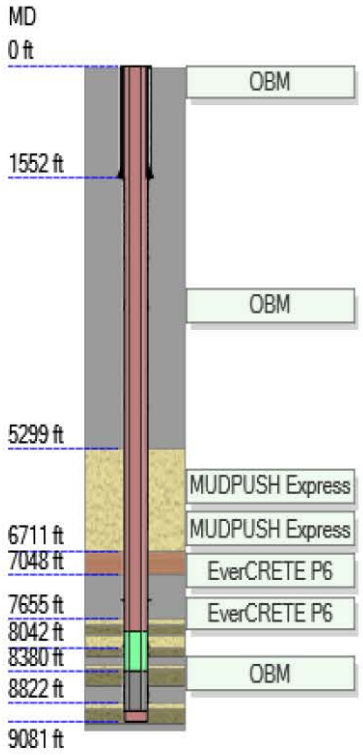
Volume Balance Model: **Optimize Slurry & Spacer**

| | | | | | |
|---|---|---|---|---|---|
| Original Fluid: | OBM | Rat Hole Fluid: | OBM | Displ. Fluid: | OBM |
| Top Spacer: | MUDPUSH Express | set Length to: | 500.0 ft | | |
| Top Slurry: | EverCRETE P8 | set Length to: | 500.0 ft | | |

Annulus is **not** filled during POOH.

## Volume Balance Results

| | | | | | |
|---|---|---|---|---|---|
| String Volume: | 158.6 bbl | Underdispl.: | -0.0 bbl | Displ. Volume: | 139.1 bbl |
| TOC after POOH: | 8428.0 ft | Cement Length after POOH: | 500.0 ft | | |




## Fluid Placement in Annulus

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.0 | 7834.5 | 7834.5 | 410.9 | 9.40 |
| MUDPUSH Express | 7834.5 | 8380.1 | 545.6 | 28.2 | 12.00 |
| EverCRETE P8 | 8380.1 | 8928.0 | 547.9 | 28.9 | 15.80 |

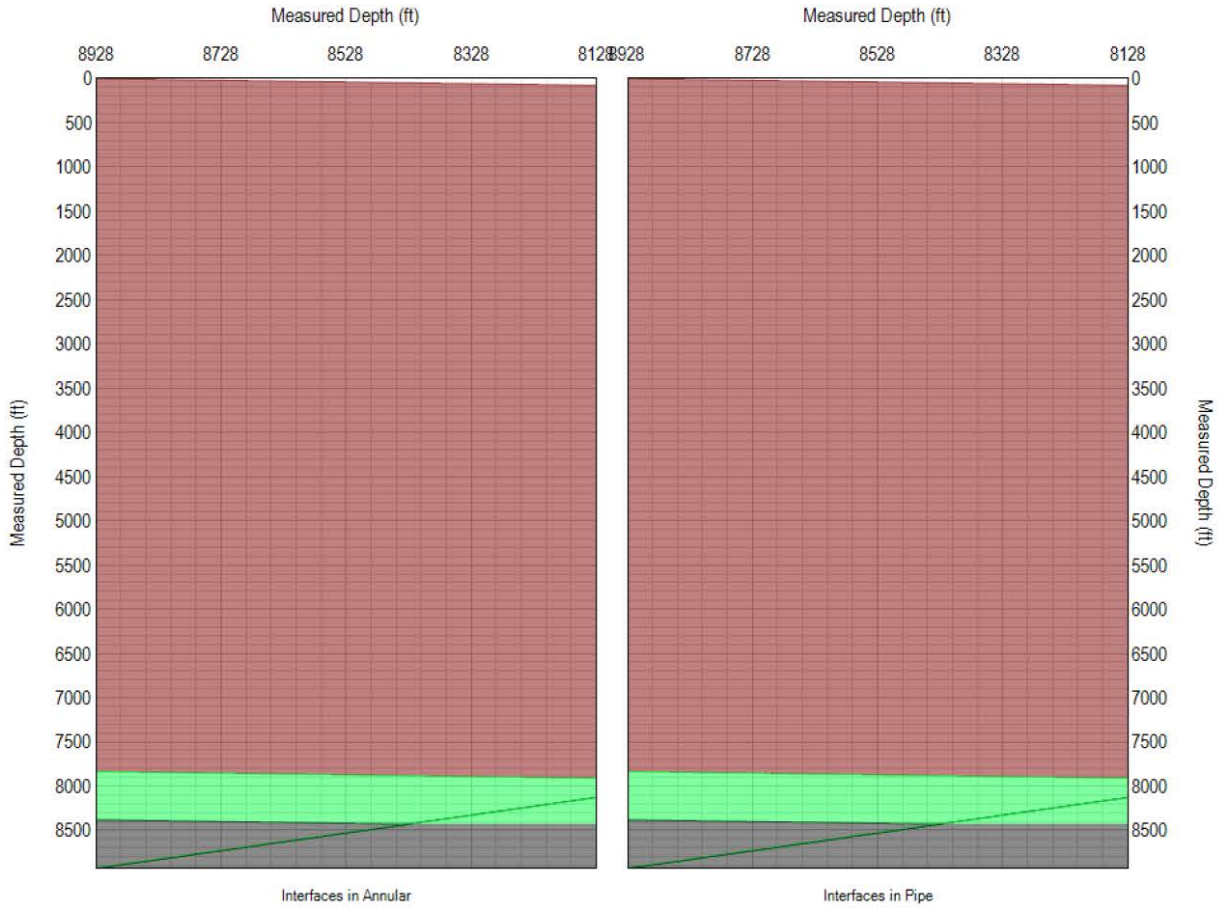
## Fluid Placement in Pipe

| Fluid Name | Top MD ft | Bottom MD ft | Length ft | Volume bbl | Surface Density lb/gal |
|---|---|---|---|---|---|
| OBM | 0.0 | 7833.8 | 7833.8 | 139.1 | 9.40 |
| MUDPUSH Express | 7833.8 | 8380.9 | 547.1 | 9.7 | 12.00 |
| EverCRETE P8 | 8380.9 | 8928.0 | 547.1 | 9.7 | 15.80 |

# Static Pull Out Of Hole (POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP Depth: | 8128.0 ft | | Theoretical Top of Plug: | 8428.0 ft |
| POOH Length: | 800.0 ft | | Theoretical Plug Length: | 500.0 ft |
| POOH Speed: | 30-40ft/min | | Plug Bottom: | 8928.0 ft |
| **Top of uncontaminated cement after POOH:** | | | | **8428.0 ft** |
| **Uncontaminated cement length after POOH:** | | | | **500.0 ft** |
| Contaminated cement length after POOH: | | | | 0.1 ft |

## POOH Results Summary




Note: Simulation assumes that fluids are free to balance themselves.

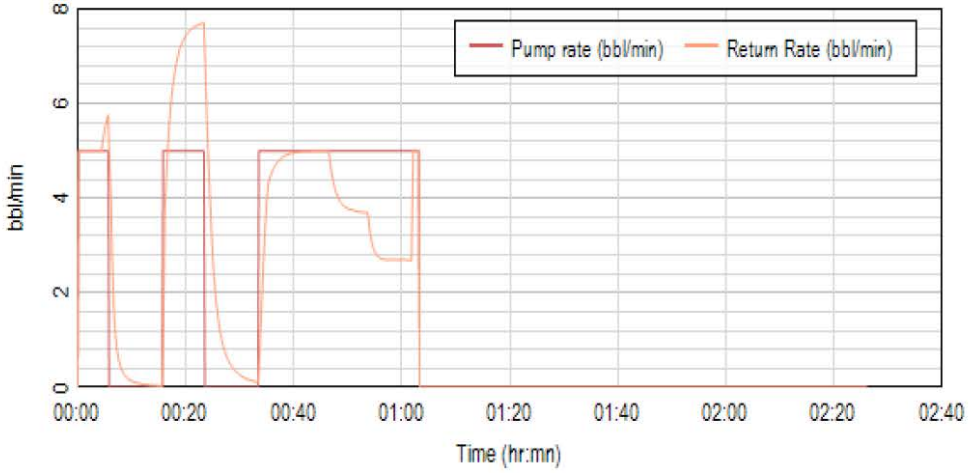
# Pumping Schedule

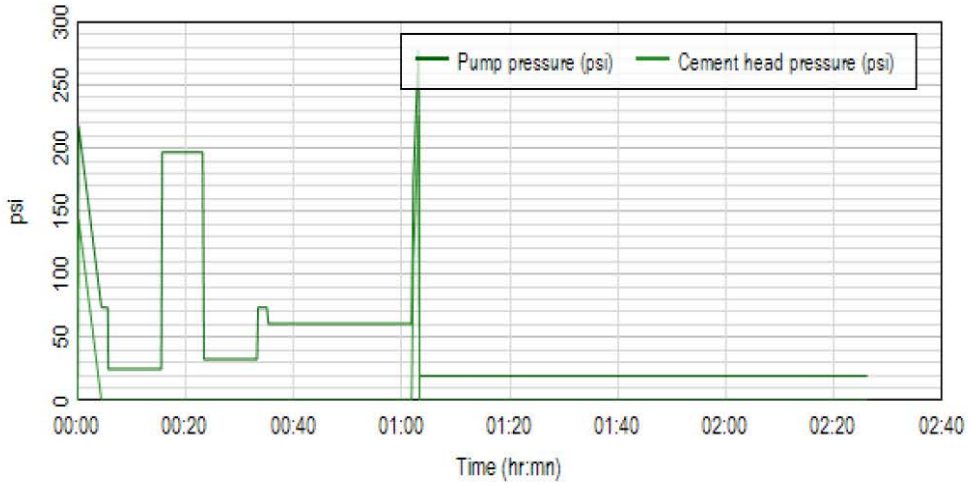
| Pumping Schedule | | | | | | |
|---|---|---|---|---|---|---|
| Fluid Name | Stage Volume bbl | Pump Rate bbl/min | Stage Time hr:mn | Cum. Time hr:mn | Comment | Inj. Temp. degF |
| Pause | | | 00:00 | 00:00 | Circ to cool down well and cond mud 120min @ 8bpm prior job (Pv ~10, Ty ~5) | |
| MUDPUSH Express | 28.2 | 5.0 | 00:06 | 00:06 | | 80.0 |
| Plug | | | 00:10 | 00:16 | Foam ball | |
| EverCRETE P8 | 38.6 | 5.0 | 00:08 | 00:23 | MinTT 4:10 | 80.0 |
| Plug | | | 00:10 | 00:33 | Foam ball | |
| MUDPUSH Express | 9.7 | 5.0 | 00:02 | 00:35 | | 80.0 |
| OBM | 139.1 | 5.0 | 00:28 | 01:03 | | 80.0 |
| Pause | | | 00:10 | 01:13 | Break cmt. lines | |
| Pause | | | 00:20 | 01:33 | POOH 300' above TOC @40'/min, rotate pipe | |
| Pause | | | 00:53 | 02:26 | Rig circ. pipe clean excess 425bbl @ 8bpm | |
| Pause | | | 00:00 | 02:26 | WOC to reach at least 500psi CS @ TOC temp. before coming in to tag plug (~10,000lbf WOB), keeping low pump rate and rotate to avoid getting stuck on gelled mixture | |
| Shut-in | | | 00:00 | 02:26 | | |

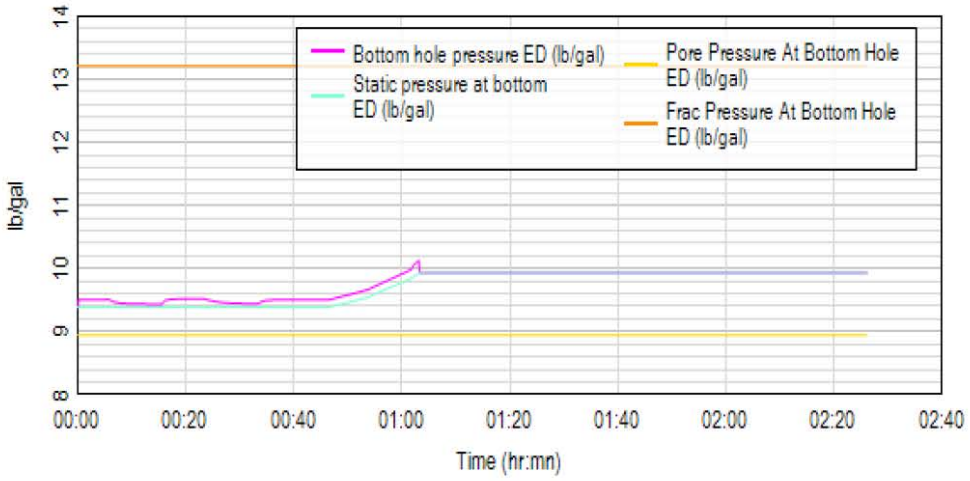
| | |
|---|---|
| Maximum Required Hydraulic Horsepower (HHP) | 34.0 hhp (at 01:03 hr:mn) |

| Displacement Volume Considerations | | |
|---|---|---|
| | Volume bbl | Variation bbl |
| Theoretical displacement volume | 139.1 | |
| Underdisplacement | | 0.0 |
| Final Displacement | 139.1 | |

Pauses in the jobs are only estimates – all efforts should be made during the operation to minimize these times.



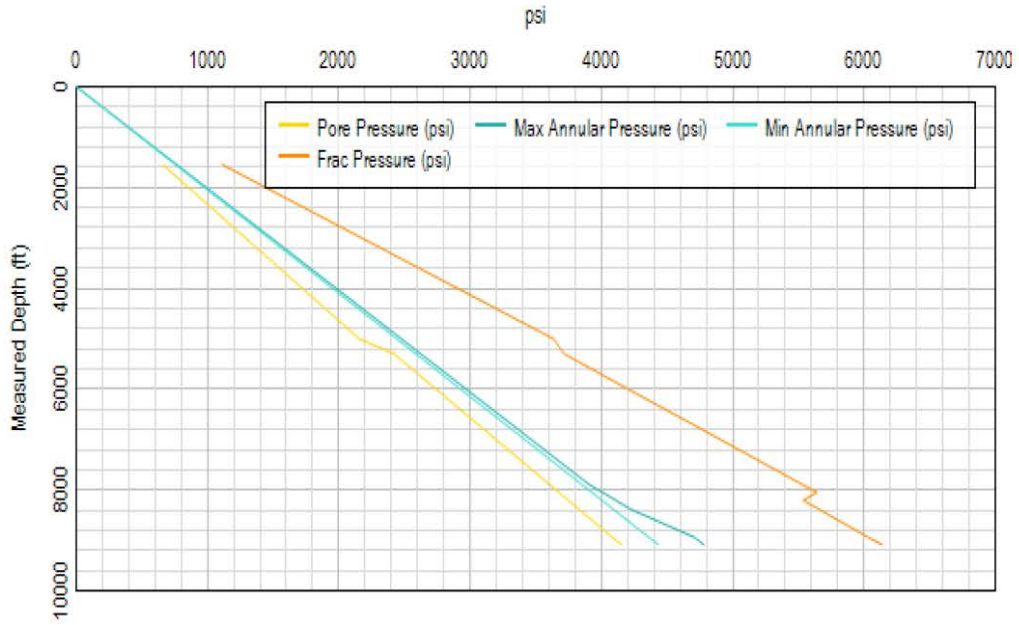

Pump pressure (psi)
Cement head pressure (psi)
psi
0
50
100
150
200
250
300
00:00
00:20
00:40
01:00
01:20
01:40
02:00
02:20
02:40
Time (hr:mn)


Bottom hole pressure ED (lb/gal)
Static pressure at bottom ED (lb/gal)
Pore Pressure At Bottom Hole ED (lb/gal)
Frac Pressure At Bottom Hole ED (lb/gal)
lb/gal
8
9
10
11
12
13
14
00:00
00:20
00:40
01:00
01:20
01:40
02:00
02:20
02:40
Time (hr:mn)

# Well Security

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 347 | 1551.5 | 00:23 |
| Success | Production/Influx | 96 | 1551.5 | 02:26 |
| Success | Burst | 9274 | 0.0 | 01:03 |
| Success | Collapse | 8814 | 4675.2 | 00:45 |

## Well Control



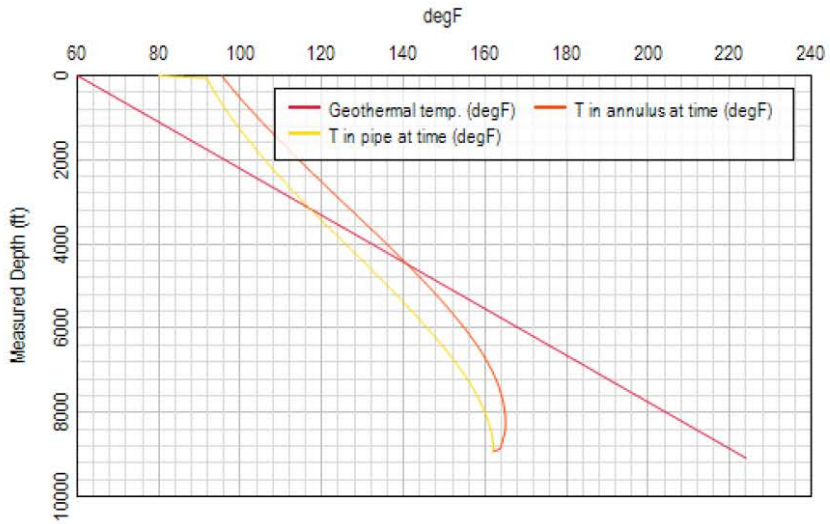
# Temperature Outputs

| | |
|---|---|
| BHST: | 221.2 degF |
| Static Temp at TOC: | 211.3 degF |

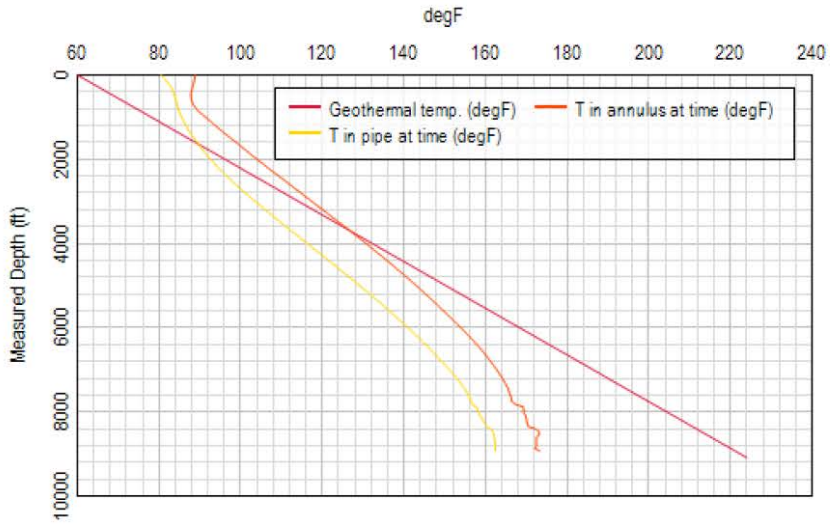
| | |
|---|---|
| Simulated BHCT: | 173.1 degF |
| Simulated HCT at TOC: | 172.2 degF |

Temperature simulation initial condition: Mud Circulation profile

## Initial Condition

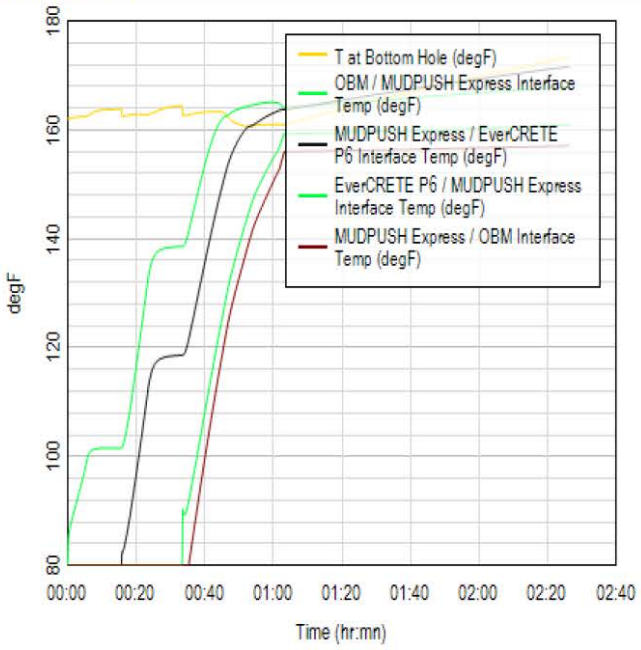



## Final Condition

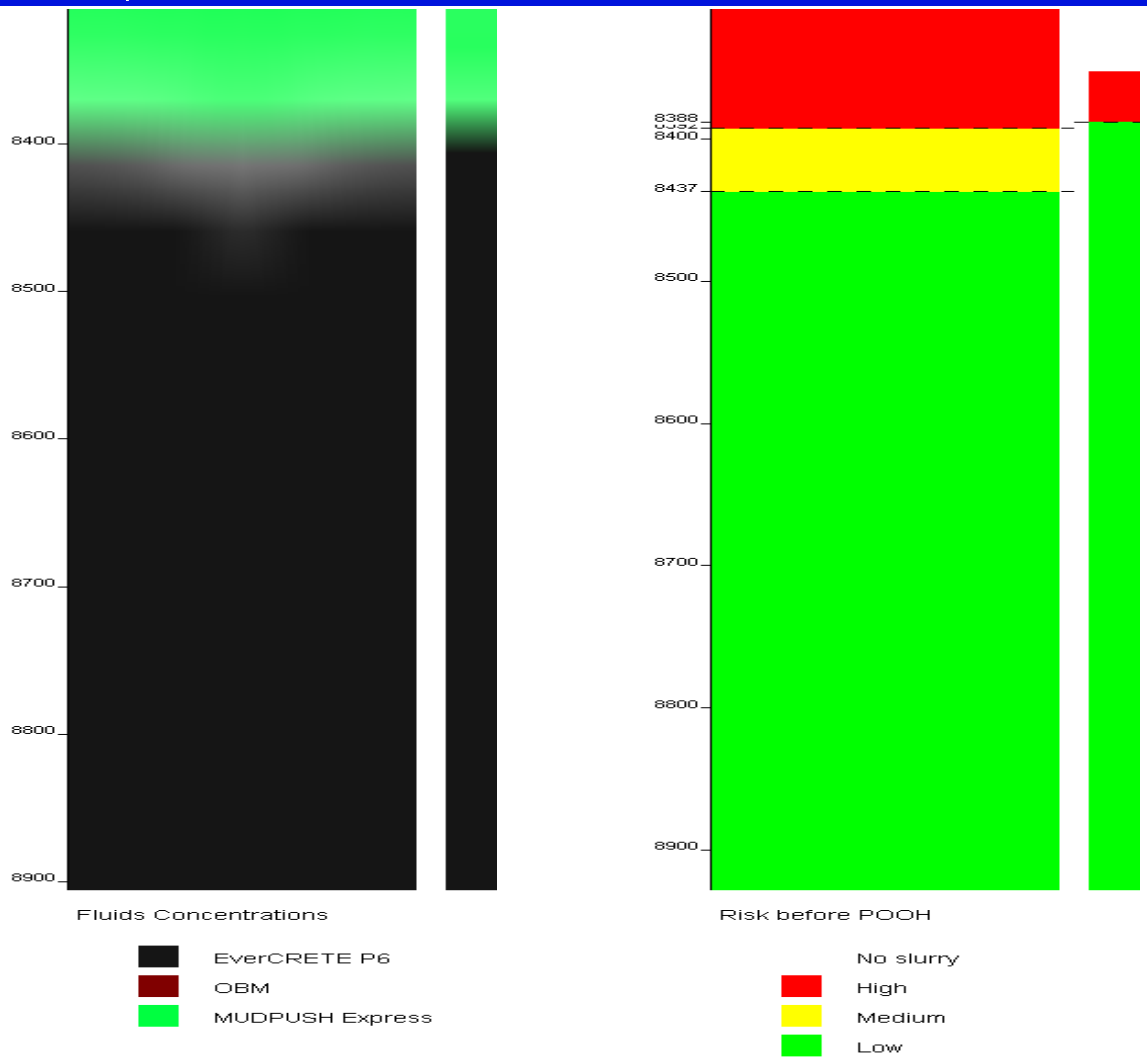



t = 02:26 hr:mn

## BHCT and Interface Temperatures



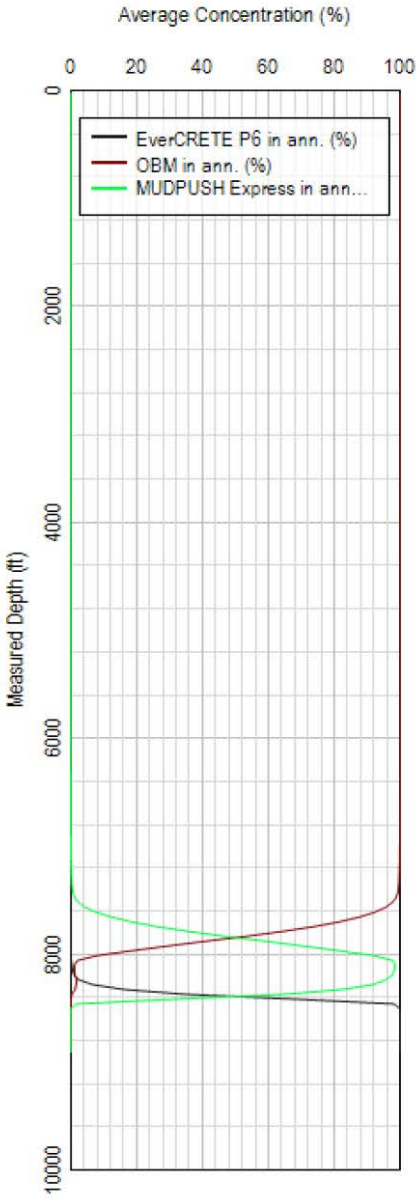
## WELLCLEAN III Maps



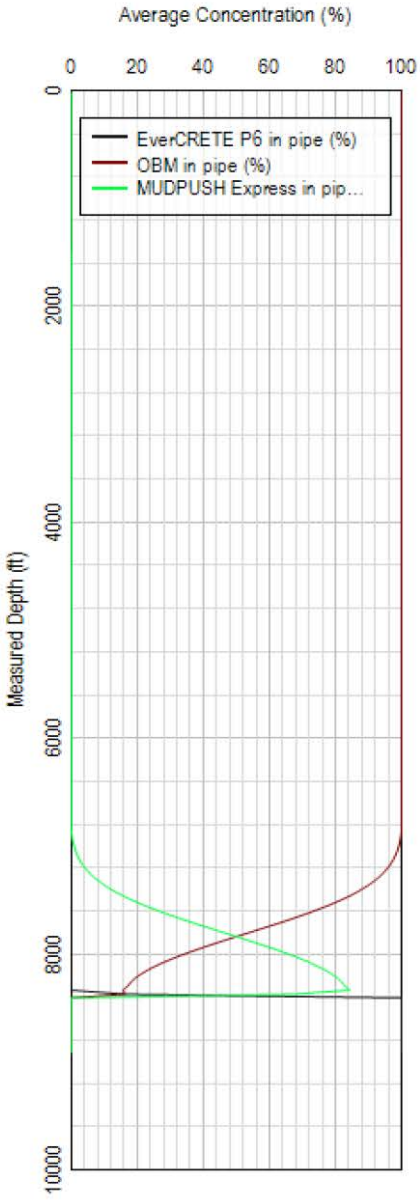

| | |
|---|---|
| **No cement slurry** | Slurry concentration is less than 10% (by unit of volume).<br>The concentration is below minimum threshold to consider that cement is present. |
| **High risk of contamination** | Slurry concentration is between 10% and 50% (by unit of volume).<br>There is no chance of finding hard cement when tagging within a few hours. |
| **Medium risk of contamination** | Slurry concentration is between 50% and 90% (by unit of volume).<br>It is possible to find some soft cement when tagging but it will most likely not be strong enough to kick off the well or even to provide a proper wellbore isolation. |
| **Low risk of contamination** | Slurry concentration is between 90% and 100% (by unit of volume).<br>Cement plug should be designed in such a way that the target of the top of cement should be within the 'green risk' zone. Hard cement should be found in that zone once compressive strength has developed, i.e. after the duration determined by the lab tests at downhole condition. |

## Fluid Concentrations before POOH

Average fluid concentration in annulus



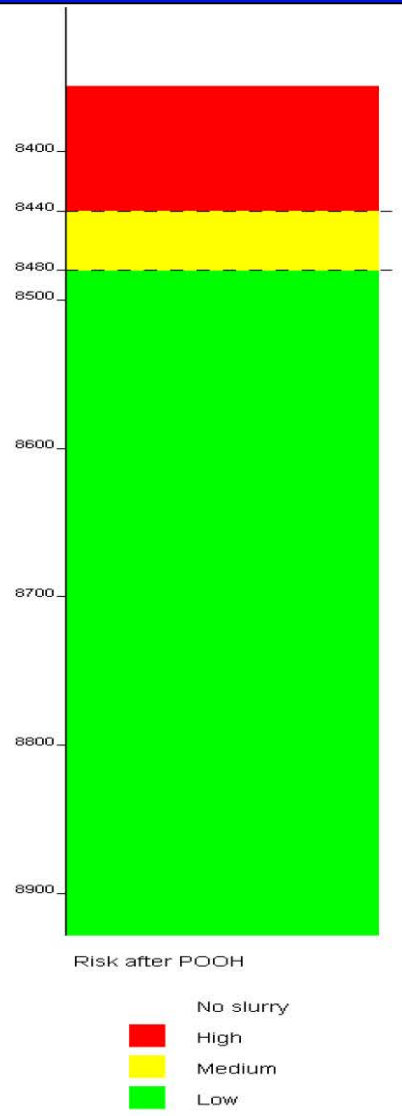

Average fluid concentration in pipe



# Final Contamination Risk (After POOH)

| POOH Summary | | | | |
|---|---|---|---|---|
| Final DP depth: | 8128.0 ft | | Theoretical Top of Plug: | 8428.0 ft |
| Theoretical Top of Plug (based on slurry volume) | | | | 8428.0 ft |
| Estimated TOC based on uncontaminated POOH simulation | | | | 8428.0 ft |
| Estimated TOC after POOH considering contamination during placement | | | | 8480.0 ft |

## Final Contamination Risk




Note: Simulation assumes that fluids are free to balance themselves

# Post-placement Circulation

Volume of compressible fluids is displayed at ambient conditions, ie. P = 1 atm and T = 60.0 degF

| | | | |
|---|---|---|---|
| DP Depth for Circulation: | 8128.0 ft | Designed TOC: | 8428.0 ft |

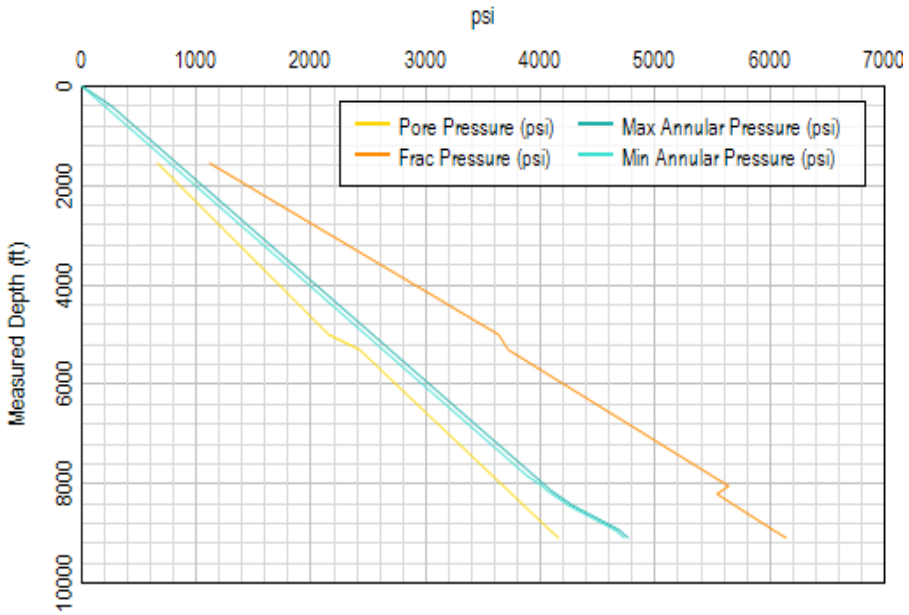
| | | | |
|---|---|---|---|
| **Circulating Fluid:** | **OBM** | Total Volume: | 422.0 bbl |
| Circulation Direction: | Direct | Number of Circulations: | 0.740 |

## Circulation Stages

| Stage | Pump Rate bbl/min | Duration hr:mn | Volume bbl | Back-pressure psi |
|---|---|---|---|---|
| OBM | 8.0 | 00:53 | 422.0 | 0 |

| Status | Description | Min. Pressure Margin psi | at Depth ft | at Time hr:mn |
|---|---|---|---|---|
| Success | Fracturing | 285 | 1551.5 | 00:51 |
| Success | Production/Influx | 108 | 1551.5 | 00:53 |
| Success | Burst | 9187 | 0.0 | 00:06 |
| Success | Collapse | 9420 | 8128.0 | 00:00 |

## Post-Placement Well Control



**Response to Specific Comments, SC-27 (Cypress Only)**

**Attachments\Form 1\Form1_Cypress I-1 Class VI_Application.pdf**

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# GEOLOGIC SEQUESTRATION

# PERMIT APPLICATION (Form 1)

## GENERAL INFORMATION AND SIGNATORY AUTHORITY

The geologic sequestration permit application consists of two parts: (1) General Information and Signatory Authority and (2) Technical Information. All sections are to be completed in order to obtain the permit to construct. Operation of a Class VI well is not authorized until authorization to inject is received from the Department. During the construction of the Class VI well, information collected may warrant a permit modification. Only sections pertaining to the modification are required to be completed and public notice requirements will only pertain to those sections being modified. **A pre-application meeting is required prior to this application being submitted.**

**Application Type**

| | | |
|---|---|---|
| UIC Class I Conversion | ☐ | UIC Class I Permit Number: |
| UIC Class II Conversion | ☐ | Hearing Number Recommending Transfer: |
| UIC Class V Conversion | ☐ | UIC Class V Permit Number: |
| New UIC Class VI | ☑ | |
| *UIC Class VI Modification | ☐ | UIC Class VI Permit Number: 2023-040 |

*For Class VI permit modifications, only the sections requiring a modification should be completed. Permit modifications require the signature of the responsible corporate officer as well as the licensed geologist, or licensed engineer, if applicable.

**Public Notice**

In accordance with W.S. 35-11-313(f)(ii)(N), the applicant shall provide notice of the application for the geologic sequestration project proposed. Proof of notice is required to surface owners, mineral claimants, mineral owners, lessees, and other owners of record of subsurface interests that are located within one (1) mile of the proposed boundary of the geologic sequestration site. The publishing of notice of the application is required in a newspaper of general circulation in each county of the proposed operation at weekly intervals for four (4) consecutive weeks. **An affidavit of the notice shall be submitted to WDEQ. Publishing of the notice may not occur more than 14 days following the submission of the permit application.**

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## Wyoming Conservation Executive Orders 2019-3 and 2020-1

### a. Sage Grouse

Pursuant to the requirements of the Governor's Executive Order 2019-3 (SGEO), applicants for new UIC permits must determine if any part of the project falls within a Greater Sage-Grouse Core Area (SGCA) before applying. If any part of the project falls within an SGCA, the first point of contact for addressing sage-grouse issues is the Wyoming Game and Fish Department (WGFD). Please coordinate with the WGFD and obtain written confirmation of consistency with the Executive Order prior to applying for a UIC permit and submit this documentation as part of the application package. For more information, contact the Wyoming Game and Fish: Wyoming Game and Fish Department Habitat Protection Program (307) 777-4506 or wgfd.hpp@wyo.gov.
Note that the application shall be returned without processing until a letter confirming consistency with the Executive Order has been obtained. Additional information and maps of SGCAs are available at https://wgfd.wyo.gov/Habitat/Sage-Grouse-Management.

Check one of the following, as applicable to the project:

☐ Some part, or all, of my project falls within an SGCA and I have contacted the WGFD for a SGEO review. A letter from the WGFD confirming consistency with the Executive Order is attached.

☐ Some part, or all, of my project falls within an SGCA and I have contacted the WGFD for a SGEO review. It does not comply with the SGEO. I have valid and existing rights related to this permit. I have committed to the following recommendations that will minimize the impact on the sage grouse.

☑ By checking this box, I certify that I have reviewed the SGCAs available online, and determined that no portion of my project falls within an SGCA. *(No additional requirements apply.)*

### b. Migration Corridors.

Pursuant to the requirements of the Governor's Executive Order 2020-1, applicants for new UIC permits must determine if any part of the project falls within a Migration Corridor designated under the Executive Order before applying. If any part of the project falls within a Migration Corridor, you must consult with the WGFD. Please coordinate with the WGFD and obtain written confirmation of consistency with the Executive Order prior to applying for a UIC permit and submit this documentation as part of the application package. For more information, contact the Wyoming Game and Fish: Wyoming Game and Fish Department Habitat Protection Program (307) 777-4506 or wgfd.hpp@wyo.gov.
Note that the application shall be returned without processing until a letter confirming consistency with the Executive Order has been obtained. Please also visit the WGFD's Management Page for more information and a map of the currently designated Migration Corridors: https://sites.google.com/view/wywildlifemigrationadvisorygrp/home?fbclid=IwAR3y_HEQxOo4HckAVKzRzT5kdLaOsyiV0vt9NJOtzNu45b_WK0vESwTWVzY#h.bc90kvcpohnu.

Check one of the following, as applicable to the project:

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☐ Some part, or all, of my project falls within the area described and I have contacted the WGFD for consultation. A letter from the WGFD confirming consistency with the Executive Order is attached.

☑ By checking this box, I certify that I have reviewed the Migration Corridors information available online, and determined that no portion of my project falls within a Migration Corridor. *(No additional requirements apply.)*

**1. General Information**

| | | | |
|---|---|---|---|
| Carbon Sequestration Project Name: Eastern Wyoming Sequestration Hub | | | |
| Owner/Operator Name Tallgrass High Plains Carbon Storage, LLC | | | |
| Responsible Corporate Officer Kyle Quackenbush | | Title Segment President & Vice President-Liquids (Crude Oil & CO2) | |
| Telephone Number 303-763-3319 | Email Address kyle.quackenbush@tallgrass.com | | |
| Owner/Operator Address 4200 West 115th Street | City Leawood | State KS | Zip 66211 |

| | | | |
|---|---|---|---|
| Facility Location Address (if different than Operator Address) | City | State | Zip |
| Telephone Number NAD 1983 Lat: 41.086491 Long: -104.214625 SWSW Sec 16 T13N R61W | | | |
| Facility Mailing Address (if different than Operator Address) | City | State | Zip |
| Telephone Number | | | |

| | | | |
|---|---|---|---|
| Consultant Name Numeric Solutions, LLC | Primary Contact Name Eric White | | |
| Consultant Address 1536 Eastman Ave Ste D | City Ventura | State CA | Zip 93003 |
| Telephone Number 805-794-5011 | Email Address eric.white@numericsolutions.com | | |
| May they be contacted directly? ☐ Yes ☑ No | | | |

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**2. Site and Facility Description**

A description of the proposed geologic sequestration facility and documentation sufficient to demonstrate that the applicant has all legal rights, including but not limited to the right to surface use, necessary to sequester carbon dioxide and associated constituents into the proposed geologic sequestration site.

| |
|---|
| The proposed Eastern Wyoming Sequestration Hub (EWS Hub) will be located in the southeastern corner of Wyoming, in Laramie County, Section 16, Township 13N, Range 61W. Additional documentation will be provided as available. |

**3. SIC Codes**

| | | |
|---|---|---|
| List in descending order of significance the four (4) digit "Standard Industrial Classification Manual" which best describes your facility in terms of the principal products or services you produce or provide. Also, specify each classification in words. | 1st | Code/Name 4619 - Pipelines, not elsewhere classified |
| | 2nd | Code/Name 4953 - Refuse systems (Nonhazardous water disposal sites) |
| | 3rd | Code/Name |
| | 4th | Code/Name |

**4. Water Quality Management Plan, Wellhead Protection Area, Source Water Protection Area**

| | | |
|---|---|---|
| Is the Geologic Sequestration Project within a state-approved water quality management plan area? | YES ☐ | NO ☑ |
| Is the Geologic Sequestration Project within a state-approved wellhead protection area? | YES ☐ | NO ☑ |
| Is the Geologic Sequestration Project within a state-approved source water protection area? | YES ☐ | NO ☑ |

**5. Mineral and Surface Ownership for Area of Review**

| | | | | | | |
|---|---|---|---|---|---|---|
| Mineral Ownership: | ☐ | Applicant | ☐ | Surface Owner | ☐ | State |
| | ☐ | Fed | Mineral Lease # See technical report | | | |

| | | | | |
|---|---|---|---|---|
| Surface Ownership: | ☐ Applicant | ☐ State | ☐ Fed | ☐ Indian Lands (Contact EPA Region 8) |
| | ☑ Private (Specify) Lease | | | ☐ Other (Specify)_____ |

| |
|---|
| Is the facility located on any historic or archeological site? Yes ☐ No ☑ |

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## 6. Contact Information

The owner or operator shall provide a list of contacts for Tribes on Indian lands within the geologic sequestration project as defined by the Area of Review.

Attach a legal description of land ownership within the Area of Review. List ownership by tract or submit in plat form.

## 7. Access for Inspections

Wyoming Statute (W.S.) 35-11-303 (a) states: "the administrator of the water quality division at the direction of the director: (i) may conduct on-site compliance inspections of all facilities and work during or following the completion of any construction, installation or modification for which a permit is issued under W.S. 35-11-301 (a)(ii)."

As part of its application, the applicant shall certify under penalty of perjury that the applicant has secured and shall maintain permission for WDEQ personnel to access the permitted facility, including (i) permission to access the land where the facility is located, (ii) permission to collect resource data as defined by W.S. § 6-3-414, and (iii) permission to enter and cross all properties necessary to access the facility if the facility cannot be directly accessed from a public road. A map of the access route(s) to the facility shall accompany the application.

> *I,* Kyle Quackenbush *, certify under penalty of perjury that the applicant has secured and shall maintain permission for WDEQ personnel and their invitees to access the permitted facility, including (i) permission to access the land where the facility is located, (ii) permission to collect resource data as defined by Wyoming Statute § 6-3-414, and (iii) permission to enter and cross all properties necessary to access the facility if the facility cannot be directly accessed from a public road.*

## 8. Comments

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**9. Certification**

All applications for permits, reports, or information submitted to the Administrator shall be signed by a responsible corporate officer.

| | | |
|---|---|---|
| "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of a fine and imprisonment for knowing violations." | | |
| Signature DocuSigned by: Kyle Quackenbush 95601045D45742D... | Printed Name Kyle Quackenbush | |
| Title Segment President and VP - Liquids (Crude Oil and CO2) | | Date 7/1/2024 |

**10. Carbon Dioxide Stream Exclusion**

The definition of the "carbon dioxide stream" means carbon dioxide, plus associated substances derived from the source materials and any processing, and any substances added to the stream to enable or improve the injection process. Within Chapter 24, the term "carbon dioxide stream" does not include any carbon dioxide stream that meets the definition of a hazardous waste under 40 CFR 261.3. Any Class VI UIC well owner or operator, who claims that a carbon dioxide stream is excluded under paragraph (h) of 40 CFR 261.4 must have an authorized representative (as defined in WWQR Chapter 24 Section 2(mm)) sign a certification statement worded as follows:

| | | |
|---|---|---|
| "I certify under penalty of law that the carbon dioxide stream that I am claiming to be excluded under 40 CR 261.4(h) has not been mixed with, or otherwise co-injected with, hazardous waste at the UIC Class VI permitted facility, and that injection of the carbon dioxide stream is in compliance with the applicable requirements for UIC Class VI wells, including the applicable requirements in WWQR Chapter 24." | | |
| Signature DocuSigned by: Kyle Quackenbush 95601045D45742D... | Printed Name Kyle Quackenbush | |
| Title Segment President and VP - Liquids (Crude Oil and CO2) | | Date 7/1/2024 |

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# GEOLOGIC SEQUESTRATION

## PERMIT APPLICATION

## TECHNICAL INFORMATION

The geologic sequestration permit application consists of two parts: General Information and Signatory Authority and Technical Information. Operation of a Class VI well is not authorized until authorization to inject is received from the department. During the construction of the Class VI well, information collected may warrant a permit modification. Modifications will only require sections pertaining to the modification to be completed and public notice requirements will only pertain to those sections being modified.

**To expedite the review of the permit application, an application report template is provided.** The following Table of Contents and text identifies the various sections with accompanying figures, tables, and appendices to accompany the application. All sections should be completed. If a section is not applicable, please state such in the document.

If data is not available but will be collected during well construction activities, please incorporate work plans describing the work to be completed where the text indicates as-builts or collected data. After the information is collected during well construction activities, those sections of the permit application may be revised as part of the permit modification to include as-builts and data collected. Additional figures and tables may be incorporated into the document and renamed to reflect site-specific information.

A Word document is provided to assist with completing the document. The italicized text should be deleted and replaced with site-specific information. If you have additional questions or need further clarification, please contact Lily Barkau at (307) 777-7072 or lily.barkau@wyo.gov or Graeme Finley at (307) 473-3478 or graeme.finley@wyo.gov.

Lily Barkau <lily.barkau@wyo.gov>

# Re: EXTERNAL: Tallgrass RTC

1 message

**Tyler Harris** <tyler.harris@wyo.gov> Thu, Jul 11, 2024 at 12:14 PM
To: "Larson, Katy" <katy.larson@tallgrass.com>
Cc: "Barkau, Lily" <lily.barkau@wyo.gov>

Thanks Katy, that should suffice.

Regards,

**Tyler Harris, P.G.**
Geology Supervisor - UIC Class VI Program
Water Quality Division, Groundwater Section
Wyoming Department of Environmental Quality

(307) 777-7608
tyler.harris@wyo.gov

***Electronic Document Uploads:***
**Water Quality Division Document Uploads**

***Mailing Address:***
200 W. 17th St. 2nd Floor
Cheyenne, WY 82002

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

On Thu, Jul 11, 2024 at 12:06 PM Larson, Katy <katy.larson@tallgrass.com> wrote:

> Please let me know if this is sufficient.
>
> Regards,
>
> **Katy Larson** | Geoscience Compliance Manager | Tallgrass Energy
>
> T: 661.383.0879 | M: 661.203.0850
>
> katy.larson@tallgrass.com

**From:** Tyler Harris <tyler.harris@wyo.gov>
**Sent:** Thursday, July 11, 2024 10:38 AM
**To:** Larson, Katy <katy.larson@tallgrass.com>
**Cc:** Barkau, Lily <lily.barkau@wyo.gov>
**Subject:** Re: EXTERNAL: Tallgrass RTC

**EXTERNAL:** This email originated from an external source. Only open attachments or click on links if you are expecting them. Report any suspicious emails using Phish Alert on your email toolbar.

Thanks Katy,

For clarification, we would just need you to submit a statement that the SRT's will be conducted with freshwater, or that the analysis of the gel fluid would be submitted for review and approval prior to conducting the SRT.

An submission via email will suffice.

Thanks,

**Tyler Harris, P.G.**

Geology Supervisor - UIC Class VI Program

Water Quality Division, Groundwater Section

Wyoming Department of Environmental Quality

(307) 777-7608

tyler.harris@wyo.gov

***Electronic Document Uploads:***

**Water Quality Division Document Uploads**

***Mailing Address:***

200 W. 17th St. 2nd Floor

Cheyenne, WY 82002

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

On Thu, Jul 11, 2024 at 11:30 AM Larson, Katy <katy.larson@tallgrass.com> wrote:

> Hi Tyler,
>
> This is reasonable.  Please let me know if you need me to submit anything further to clarify.
>
> **Katy Larson** | Geoscience Compliance Manager | Tallgrass Energy
>
> T: 661.383.0879 | M: 661.203.0850
>
> katy.larson@tallgrass.com
>
> 
> 
>
> ---
>
> **From:** Tyler Harris <tyler.harris@wyo.gov>
> **Sent:** Thursday, July 11, 2024 10:28 AM
> **To:** Larson, Katy <katy.larson@tallgrass.com>
> **Cc:** Barkau, Lily <lily.barkau@wyo.gov>
> **Subject:** EXTERNAL: Tallgrass RTC
>
> **EXTERNAL:** This email originated from an external source. Only open attachments or click on links if you are expecting them. Report any suspicious emails using Phish Alert on your email toolbar.
>
> Hey Katy,
>
> I wanted to follow-up on one thing in the response to comments dated July 5, 2024 for the Barberry, Azalea, Spirea, Old Barberry, and Cypress wells. In the response to Original Specific Comment No. 5, the discussion of the proposed SRT includes the following language:
>
> *"To properly create the fracture breakdown and accurately measure the closure stress and true fracture pressure, may require using a heavy gelled and potentially cross-linked viscous fracturing fluid."*
>
> Until an authorization to inject is issued, only freshwater is allowed to be injected for well testing purposes. Therefore, we would either need a demonstration that the proposed fluid is comparable to freshwater, including SDS sheets, chemical analysis, etc., or the SRT would have to be run with freshwater.

That is the only comment that I have for the RTC, please let me know if you have any questions or if you would like to discuss.

Thanks,

**Tyler Harris, P.G.**

Geology Supervisor - UIC Class VI Program

Water Quality Division, Groundwater Section

Wyoming Department of Environmental Quality

(307) 777-7608

tyler.harris@wyo.gov

***Electronic Document Uploads:***

**Water Quality Division Document Uploads**

***Mailing Address:***

200 W. 17th St. 2nd Floor

Cheyenne, WY 82002

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E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

11 July 2024

**VIA E-MAIL**

Wyoming Department of Environmental Quality
c/o Lily Barkau
200 West 17th Street
Cheyenne, Wyoming 82002
Lily.Barkau@wyo.gov
cc: Tyler.Harris@wyo.gov

*Submitted via email to Lily Barkau and Tyler Harris*
*Permits: 2023-039, 2023-264, 2023-041, 2023-263, 2023-040*

Dear Ms. Barkau:

High Plains recognizes that until an authorization to inject is issued, only freshwater is allowed to be injected for well testing purposes. Therefore, High Plains would either demonstrate that the proposed fluid is comparable to freshwater, including SDS sheets, chemical analysis, etc., or the SRT will be run with freshwater.

Kind Regards,

Katy Larson

Katy Larson
Geoscience Compliance Manager
Tallgrass Energy Partners, LP

13 July 2024

**VIA E-MAIL**

Wyoming Department of Environmental Quality
c/o Lily Barkau
200 West 17th Street
Cheyenne, Wyoming 82002
Lily.Barkau@wyo.gov
cc: Tyler.Harris@wyo.gov

*Submitted via email to Lily Barkau and Tyler Harris*
*Permits: 2023-039, 2023-264, 2023-041, 2023-263, 2023-040*

Dear Ms. Barkau:

High Plains is providing corrections to the operations monitoring cost estimate amounts for the Old Barberry I-1 and the Cypress I-1 injector wells. The ERR cost estimates have been adjusted for Old Barberry I-1, Cypress I-1, Azalea I-1, and Barberry I-1.

Tables 2, 9, and 15 of the Old Barberry I-1 have been updated to reflect a corrected Testing and Monitoring amount of $975,903 and ERR value of $164,090. See the following tables:

| **Activity Estimated Total Cost** | |
|---|---|
| Corrective Action on Wells in the AOR | $0 |
| Testing and Monitoring | $975,903 |
| Plugging of Old Barberry I-1 | $597,000 |
| Post-Injection Site Care and Facility Closure | $18,672,345 |
| Emergency and Remedial Response (including endangerment to USDWs) | $164,090 |
| **Total** | **$20,409,338** |

| Injection Period Testing and Monitoring | |
|---|---|
| **Occurrence** | |
| 2D Time-lapse Seismic Survey (1/6$^{th}$ of $2,808,000) | $468,000 |
| Soil Gas Monitoring | $7,725 |
| Groundwater Monitoring | $144,000 |
| Air Monitoring | $61,728 |
| Testing and Monitoring Logs Annual | $79,950 |
| Testing and Monitoring Logs Quinquennial | $214,500 |
| **Total** | **$975,903** |

| Financial Responsibility Element | Cost Estimate | When Funded |
|---|---|---|
| A. Corrective Action: | $0 | Prior to well construction |
| B. Injection Well Plugging | $597,000 | Prior to well construction |
| C. PISC and Site Closure – Monitor Well | $3,913,200 | Prior to well construction |
| D. PISC and Site Closure – Site Remediation | $600,000 | Prior to well construction |
| E. PISC Testing & Monitoring | $14,159,145 | Prior to well construction |
| **Total Cost Prior to Well Construction:** | | **$19,269,345** |
| F. Emergency and Remedial Response | $164,090 | Prior to Authorization to Inject |
| **Total Cost Prior to Authorization to Inject:** | | **$164,090** |
| G. Operation and Maintenance During Testing and Monitoring – Injection Period | $975,903 | Fully funded after one year |
| **One (1) Year After Injections Begin:** | | **$975,903** |

Tables 2, 9, and 15 of the Cypress I-1 have been updated to reflect a corrected Testing and Monitoring amount of $6,794,598 and an ERR value of $2,385,394. See the following tables:

| Activity Estimated Total Cost | |
|---|---|
| Corrective Action on Wells in the AOR | $0 |
| Testing and Monitoring | $6,794,598 |
| Plugging of Cypress I-1 | $597,000 |
| Post-Injection Site Care and Facility Closure | $13,837,412 |
| Emergency and Remedial Response (including endangerment to USDWs) | $2,385,394 |
| **Total** | **$23,614,404** |

| Injection Period Testing and Monitoring | |
|---|---|
| | |
| 2D Time-lapse Seismic Survey (1/6$^{th}$ of $2,808,000) | $468,000 |
| Soil Gas Monitoring | $123,600 |
| Groundwater Monitoring | $2,304,000 |
| Air Monitoring | $987,648 |
| Testing and Monitoring Logs Annual | $1,838,850 |
| Testing and Monitoring Logs Quinquennial | $1,072,500 |
| **Total** | **$6,794,598** |

| Financial Responsibility Element | Cost Estimate | When Funded |
|---|---|---|
| A. Corrective Action: | $0 | Prior to well construction |
| B. Injection Well Plugging | $597,000 | Prior to well construction |
| C. PISC and Site Closure – Monitor Well | $2,941,200 | Prior to well construction |
| D. PISC and Site Closure – Site Remediation | $600,000 | Prior to well construction |
| E. PISC Testing & Monitoring | $10,296,412 | Prior to well construction |
| **Total Cost Prior to Well Construction:** | | **$14,434,612** |
| F. Emergency and Remedial Response | $2,385,394 | Prior to Authorization to Inject |
| **Total Cost Prior to Authorization to Inject:** | | **$2,385,394** |
| G. Operation and Maintenance During Testing and Monitoring – Injection Period | $283,108 | After one (1) year of injection |
| **One (1) Year After Injections Begin:** | | **$283,108** |

| Financial Responsibility Element | Cost Estimate | When Funded |
|---|---|---|
| Financial Responsibility Element - years 2-end of injection | Cost Estimate | When Funded |
| Operation and Maintenance During Testing and Monitoring – Injection Period | $6,511,489.75 | Within thirty (30) days of the anniversary date of submittal of original financial assurance listed on Row G of Table 9. |
| **Total Cost for year 2-24 of Injection:** | | **$6,511,490** |

Tables 2 and 15 of the Azaelea I-1 have been updated to reflect a corrected ERR amount of $3,700,924. See the following tables:

| Activity Estimated Total Cost | |
|---|---|
| Corrective Action on Wells in the AOR | $0 |
| Testing and Monitoring | $8,342,610 |
| Plugging of Azalea I-1 | $597,000 |
| Post-Injection Site Care and Facility Closure | $12,548,350 |
| Emergency and Remedial Response (including endangerment to USDWs) | $3,700,924 |
| **Total** | **$25,188,884** |

| Financial Responsibility Element | Cost Estimate | When Funded |
|---|---|---|
| A. Corrective Action: | $0 | Prior to well construction |
| B. Injection Well Plugging | $597,000 | Prior to well construction |
| C. PISC and Site Closure – Monitor Well | $2,682,000 | Prior to well construction |
| D. PISC and Site Closure – Site Remediation | $600,000 | Prior to well construction |
| E. PISC Testing & Monitoring | $9,266,350 | Prior to well construction |
| **Total Cost Prior to Well Construction:** | | **$13,145,350** |
| F. Emergency and Remedial Response | $3,700,924 | Prior to Authorization to Inject |
| **Total Cost Prior to Authorization to Inject:** | | **$3,700,924** |
| G. Operation and Maintenance During Testing and Monitoring – Injection Period | **$278,087** | After one (1) year of injection |
| **One (1) Year After Injections Begin:** | | **$278,087** |

Tables 2 and 15 of the Barberry I-1 have been updated to reflect a corrected ERR amount of $3,125,204. See the following tables:

| Activity Estimated Total Cost | |
|---|---|
| Corrective Action on Wells in the AOR | $315,000 |
| Testing and Monitoring | $8,342,610 |
| Plugging of Barberry I-1 | $597,000 |
| Post-Injection Site Care and Facility Closure | $12,548,350 |
| Emergency and Remedial Response (including endangerment to USDWs) | $3,125,204 |
| **Total** | **$24,928,164** |

| Financial Responsibility Element | Cost Estimate | When Funded |
|---|---|---|
| A. Corrective Action: | $315,000 | Prior to well construction |
| B. Injection Well Plugging | $597,000 | Prior to well construction |
| C. PISC and Site Closure – Monitor Well | $2,682,000 | Prior to well construction |
| D. PISC and Site Closure – Site Remediation | $600,000 | Prior to well construction |
| E. PISC Testing & Monitoring | $9,266,350 | Prior to well construction |
| **Total Cost Prior to Well Construction:** | | **$13,460,350** |
| F. Emergency and Remedial Response | $3,125,204 | Prior to Authorization to Inject |
| **Total Cost Prior to Authorization to Inject:** | | **$3,125,204** |
| G. Operation and Maintenance During Testing and Monitoring – Injection Period | $278,087 | After one (1) year of injection |
| **One (1) Year After Injections Begin:** | | **$278,087** |

Kind Regards,

Katy Larson

Katy Larson
Geoscience Compliance Manager
Tallgrass Energy Partners, LP

Lily Barkau <lily.barkau@wyo.gov>

# RE: EXTERNAL: Updated tables

1 message

**Larson, Katy** <katy.larson@tallgrass.com> Sun, Jul 14, 2024 at 8:59 PM
To: "Barkau, Lily" <lily.barkau@wyo.gov>
Cc: "Harris, Tyler" <tyler.harris@wyo.gov>

Lily,

The answer on the well penetrations took a bit longer than expected due to incorrect API numbers in databases .

Attached is a spreadsheet with information demonstrating that the top of the seal is not penetrated by the wells in question.

Please let me know if you need anything further.

**Katy Larson** | Geoscience Compliance Manager | Tallgrass Energy

T: 661.383.0879 | M: 661.203.0850

katy.larson@tallgrass.com

**From:** Lily Barkau <lily.barkau@wyo.gov>
**Sent:** Saturday, July 13, 2024 8:00 PM
**To:** Larson, Katy <katy.larson@tallgrass.com>
**Cc:** Harris, Tyler <tyler.harris@wyo.gov>
**Subject:** Re: EXTERNAL: Updated tables

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Thank you, that helps me a lot.

Lily R. Barkau, P.G.

Groundwater Section Manager

Water Quality Division

200 W. 17th St. 2nd Floor, Cheyenne, WY 82002

Phone: 307-777-7072 | Fax: 307-635-1784

lily.barkau@wyo.gov

**NOTE:** WDEQ/WQD is going paperless! Please submit documents electronically to the WDEQ/WQD Groundwater Section through this link: **Water Quality Division Document Uploads**

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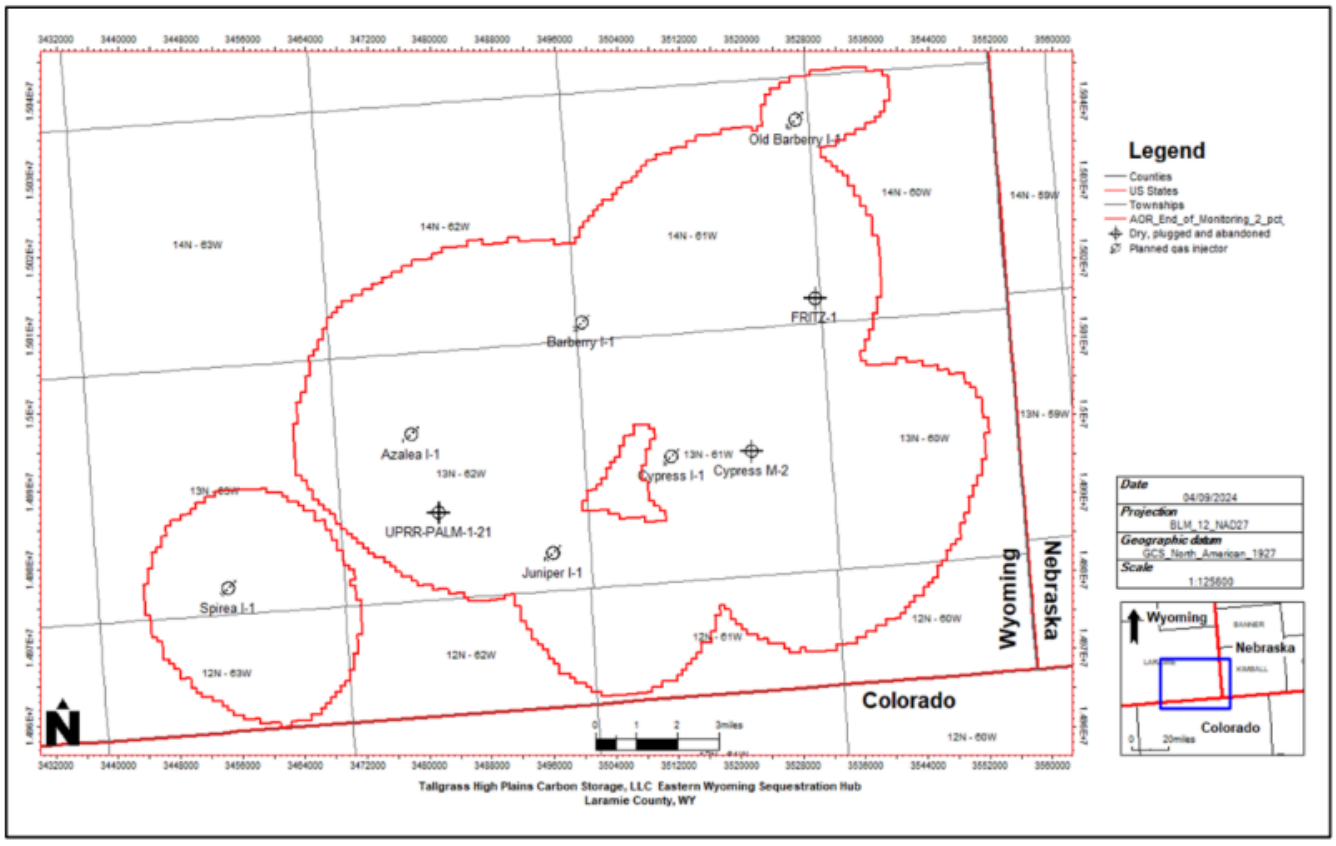
On Sat, Jul 13, 2024 at 8:57 PM Larson, Katy <katy.larson@tallgrass.com> wrote:

> This is the map that I have. Juniper M-1 is associated with Juniper I-1 FA. Fritz is associated with Barberry I-1 FA. UPRR is associated with Azalea was not determined to need CA.
>
> Financial Assurance Update_Azalea_RTC1 .pdf map can be found here.

---

**From:** Lily Barkau <lily.barkau@wyo.gov>
**Sent:** Saturday, July 13, 2024 7:51 PM
**To:** Larson, Katy katy.larson@tallgrass.com




**Cc:** Harris, Tyler <tyler.harris@wyo.gov>
**Subject:** Re: EXTERNAL: Updated tables

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Thank you. So to clarify, Azalea has no wells in its AOR that require corrective action or will Juniper be part of that?

Lily R. Barkau, P.G.

Groundwater Section Manager

Water Quality Division

200 W. 17th St. 2nd Floor, Cheyenne, WY 82002

Phone: 307-777-7072 | Fax: 307-635-1784

lily.barkau@wyo.gov

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On Sat, Jul 13, 2024 at 8:32 PM Larson, Katy <katy.larson@tallgrass.com> wrote:

> Hi Lily,
>
> Fritz should be part of Barberry. Here is the FA submission with the details: Financial Assurance Barberry Update_RTC1.pdf
>
> This is included on the spreadsheet that you sent. Once TG separated out the plumes into individual FA sections, the Fritz became associated with the Barberry.
>
> Katy
>
> ---
>
> **From:** Lily Barkau <lily.barkau@wyo.gov>
> **Sent:** Saturday, July 13, 2024 6:24 PM
> **To:** Larson, Katy <katy.larson@tallgrass.com>
> **Cc:** Harris, Tyler <tyler.harris@wyo.gov>
> **Subject:** Re: EXTERNAL: Updated tables
>
> **EXTERNAL:** This email originated from an external source. Only open attachments or click on links if you are expecting them. Report any suspicious emails using Phish Alert on your email toolbar.
>
> I don't have financial assurance calculated for Fritz 1 but the summary (section 1.8 of the Azalea application) notes that remedial work on Fritz 1 will occur prior to CO2 injection.
>
> Why is no financial assurance corrective action identified for this well? Have corrective action plans been submitted for Fritz 1?
>
> Lily
>
> Lily R. Barkau, P.G.
>
> Groundwater Section Manager

Water Quality Division

200 W. 17th St. 2nd Floor, Cheyenne, WY 82002

Phone: 307-777-7072 | Fax: 307-635-1784

lily.barkau@wyo.gov

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On Sat, Jul 13, 2024 at 5:45 PM Larson, Katy <katy.larson@tallgrass.com> wrote:

> Here you go:
>
> **Katy Larson** | Geoscience Compliance Manager | Tallgrass Energy
>
> T: 661.383.0879 | M: 661.203.0850
>
> katy.larson@tallgrass.com
>
> TALLGRASS
> Leading Energy Solutions
>
> ---
>
> **From:** Lily Barkau <lily.barkau@wyo.gov>
> **Sent:** Saturday, July 13, 2024 4:40 PM
> **To:** Larson, Katy <katy.larson@tallgrass.com>
> **Cc:** Harris, Tyler <tyler.harris@wyo.gov>
> **Subject:** Re: EXTERNAL: Updated tables
>
> **EXTERNAL:** This email originated from an external source. Only open attachments or click on links if you are expecting them. Report any suspicious emails using Phish Alert on your email toolbar.
>
> If you could resubmit those two tables or the entire letter sent earlier today, that would be great. Since I knew those were coming, I finalized the files and moving on to drafting the documents.
>
> Lily
>
> Lily R. Barkau, P.G.
>
> Groundwater Section Manager
>
> Water Quality Division
>
> 200 W. 17th St. 2nd Floor, Cheyenne, WY 82002
>
> Phone: 307-777-7072 | Fax: 307-635-1784
>
> lily.barkau@wyo.gov

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On Sat, Jul 13, 2024 at 5:39 PM Larson, Katy <katy.larson@tallgrass.com> wrote:

> Do you need me to resubmit anything? Just saw you sent Kyle the completeness letters.
>
> Katy
>
> ---
>
> **From:** Lily Barkau <lily.barkau@wyo.gov>
> **Sent:** Saturday, July 13, 2024 3:17 PM
> **To:** Larson, Katy <katy.larson@tallgrass.com>
> **Cc:** Harris, Tyler <tyler.harris@wyo.gov>
> **Subject:** EXTERNAL: Updated tables
>
> **EXTERNAL:** This email originated from an external source. Only open attachments or click on links if you are expecting them. Report any suspicious emails using Phish Alert on your email toolbar.
>
> Hi Katy,
>
> The first table, page 1 has the incorrect total. Rather than $20,245,248 it should be $20,409,338.
>
> Azalea's total activity estimated total cost is incorrect. Rather than $24,836,728 it should be $25,188,884
>
> That's it for edits needed. The rest of it all adds up.
>
> Lily
>
> Lily R. Barkau, P.G.
>
> Groundwater Section Manager
>
> Water Quality Division
>
> 200 W. 17th St. 2nd Floor, Cheyenne, WY 82002
>
> Phone: 307-777-7072 | Fax: 307-635-1784
>
> lily.barkau@wyo.gov
>
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>
> If you need a large file upload link for documents greater than 30 MB, please email **deq-ims-wqd@wyo.gov**

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**AoR Well Appendix.xlsx**
637K

DI= Drilling Info

IHS= IHS Markit

OGC= Wy Oil and Gas Conservation Commission

| API Number | Well Name | Latitude (WGS84) | Longitude (WGS84) | Operator | Spud Date | Well Status | Drill Type | Total Vertical Depth | Measured Depth (TD) | Corrected TVD | Deepest Formation Penetrated |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (DI) 49021053080000 (OGC/IHS) 49021600070000 | GROSS-WILLARD 1 | 41.166427 | -104.113194 | CHAMPLIN PETROLEUM | 11/24/1962 | DRY HOLE, P & A | V | 7,423 | 7,423 | 7,423 | Dakota |
| (DI) 49021202670000 (OGC/IHS) 49021050650000 | BARKELL 1 | 41.181058 | -104.156068 | WORLDWIDE ENERGY CORP | - | COMPLETED | V | 7,594 | 7,594 | 7,594 | Dakota |
| (DI) 49021202810000 (*North Fork 1 Bad Location*) (DI/OGC/IHS) 49021203416000 (correct North Fork 1-A location) | NORTH FORK 1-A | 41.214090 | -104.346610 | UNIOIL | 3/28/1984 | COMPLETED | V | 8,116 | 8,116 | 8,116 | Dakota Muddy J Sandstone |
| (DI) 49021600130000 (OGC) 49021202390000 (IHS) 49021053080000 | MORRITZ BROS 1-17 | 41.090762 | -104.104565 | ATLANTIC INTERNATIONAL | 7/6/1981 | UNKNOWN, P & A | V | 7,650 | 7,650 | 7,650 | Dakota /Skull Creek |
| (DI) 49021600140000 (OGC) 49021202420000 (IHS) 49021053100000 | ALLEN STATE 1-30 | 41.065481 | -104.12852 | ATLANTIC INTERNATIONAL | 6/25/1981 | UNKNOWN, P & A | V | 7,650 | 7,650 | 7,650 | Dakota /Skull Creek |
| (DI) 49021600150000 (OGC/IHS) 49021202410000 | WINTER FARMS 1-8 | 41.105238 | -104.113796 | ATLANTIC INTERNATIONAL | 7/16/1981 | UNKNOWN, P & A | V | 7,650 | 7,650 | 7,650 | Dakota /Skull Creek |
| 49021224410000 | RESOLUTION 13-63-14-23-6CH | 41.10249 | -104.39176 | OCCIDENTAL PETROLEUM | - | Abandoned Location, never drilled OGC - No Dir Survey | Abandoned Location | 7,693 (permitted) | 7,693 (permitted) | N/A | *N/A (Well Never Drilled)* |
| 49021217490000 (IHS Pilot Hole) 49021217497000 | CARPENTER 127-0429H | 41.042089 | -104.444492 | EOG RESOURCES | 2/15/2019 | OIL, ACTIVE | Pilot + Horizontal | 10,200 (permitted) 8,681 Pilot Hole 7,640 Lateral | 17,929 | 10,200 (permitted) 8,681 Pilot Hole (actual) 7,640 Lateral (actual) | Pilot Hole: Dakota Lateral: Niobrara C |
| 49021296480000 | JUNIPER M-1 | 41.059868 | -104.271948 | TALLGRASS HIGH PLAINS CARBON | 1/25/2023 | UNKNOWN, DUC | V | 9,800 | 9,800 | Okay | |
| 49021202540000 | UPRR-PALM 1-21 | 41.07318 | -104.324348 | TRANSTEXAS ENERGY | 10/14/1981 | DRY HOLE, P & A | V | 9,424 | 9,424 | Considered for CA | |
| 49021050330000 | FRITZ 1 | 41.136051 | -104.149498 | GINTHER, WARREN & GINTHER | 4/1/1938 | DRY HOLE, P & A | V | 9,015 | 9,015 | Considered for CA | |
| 49021050480000 | WW DAVIS 1 | 41.14514 | -104.11777 | SUNRAY O&G | 4/19/1956 | DRY HOLE, P & A | V | 8,669 | 8,670 | | |
| 49021201490000 | CHAMPLIN 350 | 41.058978 | -104.463925 | BP | 9/12/1976 | DRY HOLE, P & A | V | 8,600 | 8,600 | | |
| 49021200640000 | MITTAN 1 | 41.113095 | -104.376896 | INTERCONTINENTAL | 9/10/1969 | DRY HOLE, P & A | V | 8,576 | 8,576 | | |
| 49021202220000 | CHAMPLIN 325 AMOCO | 41.08399 | -104.2904 | DJ RESOURCES INC | 8/1/1980 | OIL, P & A | V | 8,408 | 8,408 | | |
| 49021202570000 | UPRR-MCNALLY FEE 1-7 | 41.018415 | -104.369148 | TRANSTEXAS ENERGY | 12/16/1981 | DRY HOLE, P & A | V | 8,284 | 8,284 | | |
| 49021201650000 | CHAMPLIN 281 | 41.149172 | -104.347034 | BP | 2/20/1977 | DRY HOLE, P & A | V | 8,290 | 8,290 | | |
| 49021201500000 | CHAMPLIN 329 AMOCO | 41.017055 | -104.3909 | BP | - | DRY HOLE, P & A | V | 8,247 | 8,247 | | |
| 49021202820000 | NORTH HEREFORD FEE 1 | 41.017783 | -104.277524 | POC ENERGY | 12/31/1982 | DRY HOLE, P & A | V | 8,100 | 8,100 | | |
| 49021207280000 | NOYER 24-10H | 41.01772 | -104.3055 | CCRP OPERATING INC | 12/13/2011 | OIL, ACTIVE | H | 8,065 | 11,635 | | |
| 49021050340000 | UPRR-ML BASTIAN 1 | 41.141785 | -104.289733 | GROSS TODD | 9/26/1938 | DRY HOLE, P & A | V | 8,018 | 8,031 | | |
| 49021201440000 | CHAMPLIN 325 AMOCO | 41.058315 | -104.257346 | BP | 7/11/1976 | DRY HOLE, P & A | V | 7,990 | 7,990 | | |
| 49021202210000 | CHAMPLIN 460 B 1 | 41.061902 | -104.142846 | BP | 7/20/1980 | DRY HOLE, P & A | V | 7,973 | 7,973 | | |
| 49021200750000 | UPRR-ROHER 1 | 41.112513 | -104.251372 | GROSS TODD | 5/21/1970 | DRY HOLE, P & A | V | 7,967 | 7,967 | | |
| 49021200760000 | BUTLER 1 | 41.109168 | -104.228575 | GROSS TODD | 9/12/1970 | DRY HOLE, P & A | V | 7,925 | 7,925 | | |
| 49021202530000 | UPRR BUTLER 1-17 | 41.087433 | -104.219304 | PRIVATE OIL | 10/12/1981 | OIL, P & A | V | 7,924 | 7,924 | | |
| 49021203070000 | BREEDEN B-16 | 41.017956 | -104.449574 | CLOVE JACK A | 3/14/1985 | DRY HOLE, P & A | V | 7,879 | 7,879 | | |
| 49021050550000 | ROHRBAUGH 1 | 41.165099 | -104.225558 | SLOSS JAMES P | 8/2/1955 | DRY HOLE, P & A | V | 7,857 | 7,857 | | |
| 49021201050000 | DOLAN 13-10 | 41.101812 | -104.190054 | DIAMONDBACK ENERGY | 8/8/1973 | DRY HOLE, P & A | V | 7,836 | 7,836 | | |
| 49021202320000 | CHAMPLIN 460 AMOCO | 41.101751 | -104.171156 | BP | 1/21/1981 | DRY HOLE, P & A | V | 7,810 | 7,810 | | |
| 49021202550000 | UPRR HRUSKA FEE 1-1 | 41.032344 | -104.144599 | TRANSTEXAS ENERGY | 10/27/1981 | DRY HOLE, P & A | V | 7,798 | 7,798 | | |
| 49021050070000 | FARR 1 | 41.058368 | -104.085807 | BRADEN OIL | 7/24/1958 | DRY HOLE, P & A | V | 7,787 | 7,787 | | |
| 49021216970000 | ARCOLA 102-3229H | 41.04435 | -104.45854 | EOG RESOURCES | 2/3/2018 | OIL, INACTIVE | H | 7,761 | - | | |
| 49021050330000 | RAUNER 1 | 41.135973 | -104.173309 | CHEVRON | 8/31/1951 | DRY HOLE, P & A | V | 7,756 | 7,756 | | |
| 49021314340000 | CARPENTER 507-0529H | 41.042158 | -104.451953 | EOG RESOURCES | - | OIL, UNKNOWN | H | 7,753 | - | | |
| 49021050600000 | ED PRESSER 1 | 41.179401 | -104.167961 | LEFTWICH J D | 1/23/1954 | DRY HOLE, P & A | V | 7,740 | 7,740 | | |
| 49021203690000 | GRAHAM 14-11 | 41.008508 | -104.400771 | GARY-WILLIAMS | 3/22/1985 | DRY HOLE, P & A | V | 7,736 | 7,736 | | |
| 49021214870000 | CARPENTER 523-0428H | 41.04194 | -104.44449 | EOG RESOURCES | 9/29/2019 | OIL, ACTIVE | H | 7,733 | 18,002 | | |
| 49021252260000 | ROCK PICK 1 | 41.09971 | -104.38082 | OCCIDENTAL PETROLEUM | 10/8/2017 | STRATIGRAPHIC/CORE TEST, P & A | D | 7,731 | - | | |
| 49021201840000 | STATE 12-31 | 41.051036 | -104.138821 | CORRIDA OIL INC | 8/16/1977 | OIL, P & A | V | 7,703 | 7,703 | | |
| 49021200540000 | MORITZ BROTHERS 1 | 41.096036 | -104.104321 | GROSS TODD | 4/1/1969 | DRY HOLE, P & A | V | 7,700 | 7,700 | | |
| 49021202000000 | GARDNER 13-9 | 41.105007 | -104.099277 | DUNCAN OIL | 6/20/1978 | DRY HOLE, P & A | V | 7,700 | 7,700 | | |
| 49021050770000 | ST JOHN 1 | 41.193868 | -104.186895 | JOHNSON D E A INC | 12/27/1955 | DRY HOLE, P & A | V | 7,690 | 7,701 | | |
| 49021208360000 | BREEDEN 2-17H | 41.01527 | -104.4567 | CCRP OPERATING INC | 10/21/2011 | OIL, ACTIVE | H | 7,686 | 11,804 | | |
| 49021200610000 | PROSSER 1 | 41.159578 | -104.170609 | GROSS TODD | 7/9/1969 | DRY HOLE, P & A | V | 7,682 | 7,682 | | |
| 49021201640000 | UPRR-GARDNER BROS 1 | 41.069149 | -104.157084 | GROSS TODD | 2/16/1977 | DRY HOLE, P & A | V | 7,679 | 7,679 | | |
| 49021050060000 | STATE 53 1 | 41.051041 | -104.142931 | SHELL | 7/17/1958 | DRY HOLE, P & A | V | 7,665 | 7,665 | | |
| 49021202580000 | UPRR-WYOBRASKA FEE 1-17 | 41.014237 | -104.120763 | TRANSTEXAS ENERGY | 11/19/1981 | DRY HOLE, P & A | V | 7,660 | 7,660 | | |
| 49021205450000 | WILHELM 2 | 41.148203 | -104.12782 | PAR PACIFIC | 7/2/2004 | OIL, P & A | V | 7,656 | 7,656 | | |
| 49021217480000 | CARPENTER 126-0408H | 41.04194 | -104.44431 | EOG RESOURCES | 7/29/2019 | OIL, ACTIVE | H | 7,651 | 17,034 | | |
| 49021202390000 | MORRITZ BROTHERS 1-A | 41.090762 | -104.104565 | ATLANTIC OIL COMPANY | 7/6/1981 | OIL, P & A | V | 7,650 | 7,650 | | |
| 49021202410000 | WINTER FARMS 1-8 | 41.105238 | -104.113796 | ATLANTIC OIL COMPANY | 7/17/1981 | OIL, P & A | V | 7,650 | 7,650 | | |
| 49021202420000 | ALLEN STATE 1-30 | 41.065481 | -104.12852 | ATLANTIC OIL | 6/26/1981 | OIL, P & A | V | 7,650 | 7,650 | | |
| 49021208880000 | GORDON 1-12H | 41.10107 | -104.37137 | GBK CORPORATION | 12/30/2011 | OIL, TA | H | 7,641 | 11,984 | | |
| 49021200990000 | UPRC-RESOURCE CORP 1 | 41.119735 | -104.142473 | TARGET OIL | 1/31/1973 | DRY HOLE, P & A | V | 7,636 | 7,636 | | |
| 49021050810000 | WILKINSON 1 | 41.20813 | -104.110154 | WESTLAND ENERGY | 10/25/1952 | DRY HOLE, P & A | V | 7,625 | 7,625 | | |
| 49021050310000 | RUBY SCHACHER 1 | 41.107203 | -104.073475 | BRADEN OIL | 12/20/1955 | DRY HOLE, P & A | V | 7,602 | 7,602 | | |
| 49021202610000 | WINTER FARMS 11-8 | 41.112336 | -104.118687 | TERRA ENERGY PARTNERS LLC | 2/24/1982 | DRY HOLE, P & A | V | 7,600 | 7,600 | | |
| 49021050650000 | BARKELL 1 | 41.177596 | -104.156025 | TRUE COMPANIES | 10/5/1955 | DRY HOLE, P & A | V | 7,594 | 7,594 | | |
| 49021201000000 | HOBBS 1 | 41.181179 | -104.165608 | POLUMBUS CORP | 2/11/1973 | DRY HOLE, P & A | V | 7,590 | 7,646 | | |
| 49021050170000 | MORRITZ 1 | 41.078112 | -104.111715 | WILLIAMS | 9/6/1955 | DRY HOLE, P & A | V | 7,555 | 7,555 | | |
| 49021050110000 | CULEX 1 | 41.069075 | -104.104708 | WYOMING OIL & DEV | 9/28/1959 | DRY HOLE, P & A | V | 7,544 | 7,544 | | |
| 49021050660000 | GROSS-WILKERSON 1 | 41.179354 | -104.148853 | NICKLE L L | 9/16/1955 | DRY HOLE, P & A | V | 7,540 | 7,540 | | |
| 49021202120000 | CARPENTER 1 | 41.141374 | -104.127925 | GROSS TODD | 9/15/1979 | DRY HOLE, P & A | V | 7,532 | 7,532 | | |
| 49021205900000 | DUELLO 34-5 | 41.20225 | -104.10725 | BEAR OIL & GAS | 4/3/2009 | OIL, P & A | V | 7,525 | 7,700 | | |
| 49021208380000 | KONIG 2-11H | 41.03031 | -104.39906 | CCRP OPERATING INC | 10/10/2012 | OIL, P & A | H | 7,505 | 11,930 | | |
| 49021201330000 | LEO JESSEN 1-5 | 41.119693 | -104.113673 | FINA OIL & CHEMICAL CO | 8/23/1976 | DRY HOLE, P & A | V | 7,493 | 7,493 | | |
| 49021050370000 | WILHELM 2 | 41.150422 | -104.130134 | C M & W DRILLING | 4/18/1956 | DRY HOLE, P & A | V | 7,480 | 7,480 | | |
| 49021203350000 | FORNSTROM 1-20 | 41.162938 | -104.113183 | HRUBETZ OIL CO. | 3/8/1984 | DRY HOLE, P & A | V | 7,480 | 7,480 | | |
| 49021050440000 | CAMPBELL 1 | 41.150305 | -104.111014 | C M & W DRILLING | 12/4/1943 | DRY HOLE, P & A | V | 7,465 | 7,469 | | |
| 49021050450000 | WILHELM 1 | 41.147693 | -104.124221 | PAR PACIFIC | 10/11/1955 | OIL, P & A | V | 7,462 | 7,462 | | |
| 49021050850000 | GH PHELPS 1 | 41.222463 | -104.090855 | GROSS TODD | 3/9/1956 | DRY HOLE, P & A | V | 7,450 | 7,450 | | |
| 49021206690000 | STATE 14-63-36-1H | 41.13122 | -104.37179 | ENCAP | 8/23/2010 | OIL, P & A | H | 7,450 | 12,695 | | |
| 49021050390000 | MORRIS 1 | 41.150422 | -104.130134 | C M & W DRILLING | 3/12/1956 | DRY HOLE, P & A | V | 7,449 | 7,449 | | |
| 49021050860000 | MORITZ FLAY 1 | 41.222646 | -104.129159 | MIDWEST OIL CORP. | 11/19/1955 | DRY HOLE, P & A | V | 7,445 | 7,570 | | |
| 49021600080000 | C FORNSTROM 1 | 41.164754 | -104.110767 | TEXAS AMERICAN OIL CORP | 5/15/1931 | DRY HOLE, P & A | V | 7,440 | 7,440 | | |
| 49021050540000 | FORNSTROM 1 | 41.170152 | -104.108321 | WYOMING OIL & DEV CO | 8/31/1955 | DRY HOLE, P & A | V | 7,434 | 7,434 | | |
| 49021052450000 | GROSS-WILKINSON 3-A | 41.188328 | -104.097903 | C & M OIL CO | 2/9/1996 | OIL, SHUT-IN | V | 7,434 | 7,434 | | |
| 49021050580000 | GROSS 3-17 | 41.173732 | -104.103457 | CENTRAL OPERATING INC | 8/21/1955 | OIL, P & A | V | 7,430 | 7,430 | | |
| 49021050780000 | WISROTH 1 | 41.182272 | -104.101786 | BRADEN OIL | 9/27/1953 | DRY HOLE, P & A | V | 7,430 | 7,430 | | |
| 49021202110000 | FORNSTROM 1-21 | 41.170076 | -104.098848 | GENERAL AMERICAN OIL CO OF TEXAS | 5/5/1979 | DRY HOLE, P & A | V | 7,427 | 7,427 | | |
| 49021052580000 | GROSS-WILLARD 1 | 41.195427 | -104.093567 | CHAMPION VENTURES INC | 11/24/1962 | DRY HOLE, P & A | U | 7,426 | - | | |
| 49021600070000 | GROSS-WILLARD 1 | 41.166682 | -104.113113 | CHAMPION VENTURES INC | 11/24/1962 | DRY HOLE, P & A | V | 7,423 | 7,423 | | |
| 49021201580000 | JESSEN 22-5 | 41.122303 | -104.112476 | HAUG LAWRENCE | 1/11/1977 | OIL, P & A | V | 7,421 | 7,421 | | |
| 49021050420000 | CAMPBELL 1 | 41.14484 | -104.103932 | WYOMING OIL & DEV | 7/1/1939 | DRY HOLE, P & A | V | 7,418 | 7,418 | | |
| 49021050820000 | CG WISROTH 1 | 41.20798 | -104.090997 | PURE OIL CO | 9/2/1957 | DRY HOLE, P & A | V | 7,414 | 7,414 | | |
| 49021050700000 | GROSS-WILKINSON 2 | 41.179203 | -104.110573 | PURE OIL CO | 10/6/1955 | DRY HOLE, P & A | V | 7,413 | 7,413 | | |
| 49021207980000 | SMITH 44-6H | 41.03191 | -104.35287 | CCRP OPERATING INC | 6/6/2012 | OIL, ACTIVE | H | 7,410 | 11,700 | | |
| 49021052530000 | WISROTH RANCH 2 | 41.192064 | -104.102504 | BRADEN OIL | 10/5/1966 | DRY HOLE, P & A | V | 7,407 | 7,407 | | |
| 49021200940000 | LEO JESSEN 2-33 | 41.140242 | -104.097599 | TARGET OIL | 10/25/1972 | DRY HOLE, P & A | V | 7,406 | 7,412 | | |
| 49021050800000 | GROSS 1 | 41.198937 | -104.093523 | MCDERMOTT J RAY & | 6/20/1947 | DRY HOLE, P & A | V | 7,403 | 7,403 | | |
| 49021050690000 | GROSS-WILKERSON 1 | 41.179203 | -104.110573 | PURE OIL CO | 4/17/1950 | DRY HOLE, P & A | V | 7,386 | 7,387 | | |
| 49021207380000 | JOHNSON 44-12H | 41.01763 | -104.375809 | CCRP OPERATING INC | 9/19/2012 | OIL, ACTIVE | H | 7,382 | 11,992 | | |
| 49021202720000 | GROSS-WILKINSON 11-9 | 41.191729 | -104.093613 | BRADEN OIL | 8/14/1982 | DRY HOLE, P & A | V | 7,368 | 7,368 | | |
| 49021052570000 | GROSS-WILKINSON 1-A | 41.18811 | -104.098142 | WYOMING WESTERN OIL | 7/22/1962 | DRY HOLE, P & A | V | 7,347 | 7,347 | | |
| 49021208590000 | SNEESBY 44-9H | 41.10089 | -104.31407 | GBK CORPORATION | 12/30/2011 | OIL, TA | H | 7,324 | 11,700 | | |
| 49021204470000 | M LAZY M 42-13 | 41.181478 | -104.255919 | NEWPORT EXPL | 3/31/1992 | DRY HOLE, P & A | V | 7,294 | 7,294 | | |
| 49021050030000 | BREEDEN 1-A | 41.02354 | -104.43768 | HAYES ROBERTSON | 6/20/1950 | DRY HOLE, P & A | V | 5,000 | 5,010 | | |
| 49021050040000 | BREEDEN 1 | 41.029981 | -104.429365 | WATKINS J N | 11/3/1949 | DRY HOLE, P & A | V | 292 | 292 | | |

## Notes:

DrillingInfo has a different API # for this well. OGC and IHS have the same API # for this well. IHS/OGC have well TVD as 7423 and penetrating the Dakota Formation

DrillingInfo has a different API # for this well. OGC and IHS have the same API # for this well. IHS/OGC have well TVD as 7594' and penetrating the Dakota Formation

Previous North Fork 1 well from DI was an error/bad location in their database. According to OGC, the only *North Fork 1* well in Wyoming is in SW Wyoming in the Green River Basin. The OGC web map doesn't show ANY well locations in Sec 23 as DI had it (*see screen capture comparison at right*) . There is a North Fork 1-A well that is a few miles to the north. I've edited the name, API, Lat/Long & Operator to be this well. The North Fork 1-A well was drilled to 8116' TVD and penetrated the Dakota Muddy J Sand

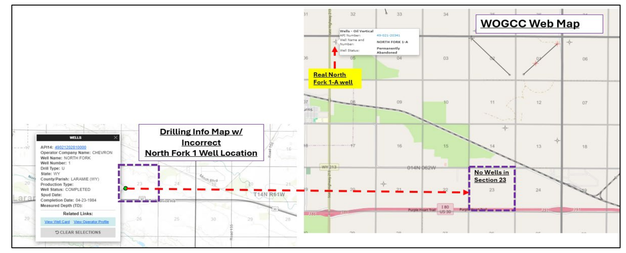
DI, OGC, & IHS all had different API #'s for the same well . IHS and OGC both have TD of well at 7650'. Deepest formation penetrated is the Skull Creek Shale

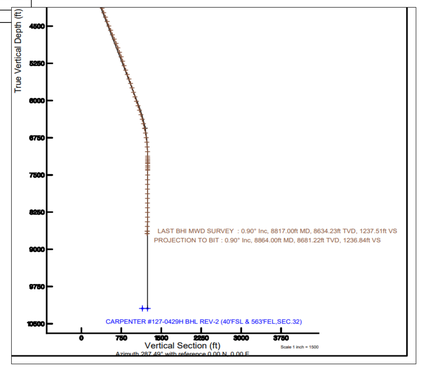
DI, OGC, & IHS all had different API #'s for the same well. IHS and OGC both have TD of well at 7650'. Deepest formation penetrated is the Skull Creek Shale

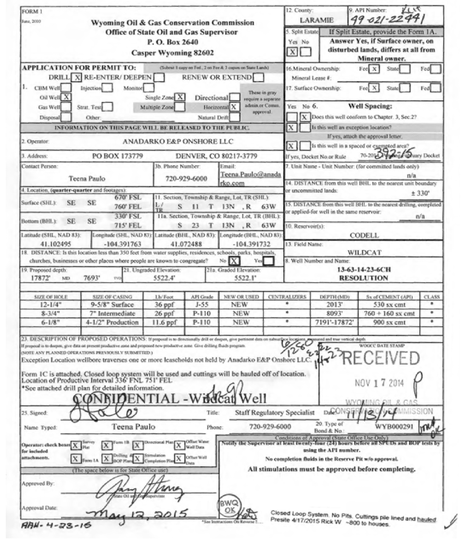
DI has a different API # for this well while OGC and IHS have the same API#. OGC and IHS have TVD as 7650' and penetrating the Dakota Formation

DI was incorrect, this well was never actually drilled. IHS/OGC both have this as an abandoned location.

10,200' was planned/permitted depth for Pilot Hole. OGC Survey of ACTUAL Pilot Hole goes to 8681' TVD at TD, and penetrating the Dakota Formation. *(See screenshot below-right)* Max TVD of Lateral is 7640' in the Niobrara C.





FORM 1
Sec. 3101

**Wyoming Oil & Gas Conservation Commission**
**Office of State Oil and Gas Supervisor**
**P. O. Box 2640**
**Casper Wyoming 82602**

12. County: LARAMIE — 13. API Number: 49-021-22749

**APPLICATION FOR PERMIT TO:** (Submit 3 copy set (Set 2 on Fed. & 3 copies on State Land))

DRILL [X] RE-ENTER/ DEEPEN [ ] RENEW OR EXTEND [ ]

1. CBM Well [ ] Injection [ ] Monitor [ ] — Single Zone [X] Directional [ ] — These items require a separate sundry or Comm. approval.
Oil Well [X] — Multiple Zone [ ] Horizontal [ ]
Gas Well [ ] Strat. Test [ ] — Natural Drift [ ]
Disposal [ ] Other [ ]

**INFORMATION ON THIS PAGE WILL BE RELEASED TO THE PUBLIC.**

2. Operator: ANADARKO E&P ONSHORE LLC

3. Address: PO BOX 173779 DENVER, CO 80217-3779

Contact Person: Teena Paulo — Ph. Phone Number: 720-929-6000 — Email: Teena.Paulo@anadarko.com

4. Location, (quarter-quarter and footage):
Surface (SHL): SE SE 670' FSL 760' FEL
Bottom (BHL): SE SE 330' FSL 715' FEL
Latitude (SHL, NAD 83): 41.102495 — Longitude (SHL, NAD 83): -104.391763
Latitude (BHL, NAD 83): 41.072488 — Longitude (BHL, NAD 83): -104.391732

11. Section, Township & Range, Lot, TR (SHL): Lot — S 11 T 13N R 63W
11a. Section, Township & Range, Lot, TR (BHL): S 23 T 13N R 63W

18. DISTANCE: Is this location less than 350 feet from water supplies, residences, schools, parks, hospitals, churches, businesses or other places where people are known to congregate? No [X] Yes [ ]

19. Proposed depth: 17872' MD 7693' TVD — 21. Elevated Elevation: 5522.4' — 21a. Graded Elevation: 5522.1'

12. Spill Estate: If Split Estate, provide the Form 1A.
Yes No [X]
Answer Yes, if Surface owner, on disturbed lands, differs at all from Mineral owner.
16. Mineral Ownership: Fed [X] State [ ] Fee [ ] — Mineral Lease #
17. Surface Ownership: Fed [X] State [ ] Fee [ ]

Well Spacing:
Yes No [X] 6. Does this well conform to Chapter 3, Sec 27
[X] Is this well an exception location?
If yes, attach the approval letter.
[X] Is this well in a spaced or unspaced area?
If yes, Docket No.or Rule — 70-2015 — Sundry Docket #
7. Unit Name - Unit Number: (for committed lands only)
n/a
14. DISTANCE from this well BHL to the nearest unit boundary or uncommitted lands: ± 330'
15. DISTANCE from this well BHL to the nearest drilling, completed or applied-for well in the same reservoir: n/a
10. Reservoir(s): CODELL
13. Field Name: WILDCAT
8. Well Number and Name: 13-63-14-23-6CH RESOLUTION

| SIZE OF HOLE | SIZE OF CASING | Lb./Foot | API Grade | NEW OR USED | CENTRALIZERS | DEPTH(MD) | Sx of CEMENT (APX) | CLASS |
|---|---|---|---|---|---|---|---|---|
| 12-1/4" | 9-5/8" Surface | 36 ppf | J-55 | NEW | * | 2013' | 530 sx cmt | * |
| 8-3/4" | 7" Intermediate | 26 ppf | P-110 | NEW | * | 8093' | 760 + 160 sx cmt | * |
| 6-1/8" | 4-1/2" Production | 11.6 ppf | P-110 | NEW | * | 7191'-17872' | 900 sx cmt | * |

22. DESCRIPTION OF PROPOSED OPERATIONS: (If proposal is to deepen/sidetrack, give present zone and proposed new production. If proposal is to drill, deepen, or plug back give present productive zone and proposed new productive zone. Give drilling fluids program. DON'T ASK PLANNED OPERATIONS PREVIOUSLY SUBMITTED.)
Exception Location wellbore traverses one or more leaseholds not held by Anadarko E&P Onshore LLC

Form 1C is attached. Closed loop system will be used and cuttings will be hauled off of location.
Location of Productive Interval 336' FNL 751' FEL
*See attached drill plan for detailed information.

CONFIDENTIAL - Wildcat Well

RECEIVED
NOV 17 2014
WYOMING OIL & GAS CONSERVATION COMMISSION

23. Signed: Teena Paulo — Title: Staff Regulatory Specialist — Date: 11/13/14
Name: Typed: Teena Paulo — Phone: 720-929-6000 — 29. Type of Bond & No.: WYB000291

Operator: check boxes for included attachments. [X] Survey Plat [X] Form 1A [X] Directional Plan [X] Other Water Well Data [X] Form 1A [X] Drlg Plan [X] Completion Plan [X] Other Well

(The space below is for State USE only)

Approved By:

Approval Date: May 13, 2015

Notify the Supervisor at least twenty-four (24) hours before all BOP tests and BOP drills by using the API number.
No completion fluids in the Reserve Pit w/o approval.
All stimulations must be approved before completing.

BWO OK — Closed Loop System. No Pits. Cuttings pile lined and hauled Presite 4/17/2015 Rick W. ~800 to houses.

HH- 4-28-15

| API Number | Well Name | Surface Latitude (NAD27) | Surface Longitude (NAD27) | BH Latitude (NAD27) | BH Longitude (NAD27) | Operator Name | Date Spud | Hole Direction | Final Status | Measured Depth (ft) | TVD Depth (ft) | Deepest Formation Penetrated |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DI) 49021600130000<br>(OGC) 49021202390000<br>(IHS) 49021053090000 | MORRITZ BROS 1-17 | 41.090799 | -104.104099 | N/A | N/A | ATLANTIC OIL CO | 7/6/1981 | VERTICAL | DRY & ABANDONED | 7525 | 7525 | DAKOTA GRP - SKULL CREEK SHALE |
| 49021295480000 | JUNIPER M-1 | 41.0559899 | -104.2713857 | 41.0559837 | -104.271446 | TALLGRASS HIGH PLAINS CARBON STORAGE LLC | 1/25/2023 | VERTICAL | MONITOR NO SHOWS | 9854 | 9852 | VIRGIL |
| (DI) 49021600150000<br>(OGC/IHS)<br>49021202410000 | WINTER FARMS 1-8 | 41.10527862 | -104.1133626 | N/A | N/A | ATLANTIC OIL CO | 7/16/1981 | VERTICAL | D&A-O | 7512 | 7512 | DAKOTA GRP - SKULL CREEK SHALE |
| 49021208380000 | KONIG 2-11H | 41.03032823 | -104.3985403 | 41.0184793 | -104.393154 | SUNDANCE ENERGY INC | 10/19/2012 | HORIZONTAL | ABD-OW | 11930 | 7459 | NIOBRARA B |
| 49021208880000 | GORDON 1-12H | 41.10108381 | -104.3708574 | 41.1139679 | -104.370857 | KAISER-FRANCIS OIL CO | 12/26/2013 | HORIZONTAL | OIL PRODUCER | 11984 | 7632 | CODELL |
| 49021208887000 | GORDON 1-12H | 41.10108381 | -104.3708574 | 41.1011926 | -104.370913 | KAISER-FRANCIS OIL CO | 4/4/2012 | VERTICAL | PILOT HOLE | 8200 | 8199 | DAKOTA J SILT |
| 49021208890000 | SNEESBY 44-9H | 41.10090757 | -104.313561 | 41.1127957 | -104.318786 | FIDELITY EXPLORATION & PRODUCTION CO | 2/23/2012 | HORIZONTAL - ST | ABD-OW | 11700 | 7308 | NIOBRARA B |
| 49021208897000 | SNEESBY 44-9H | 41.10090757 | -104.313561 | N/A | N/A | FIDELITY EXPLORATION & PRODUCTION CO | 2/4/2012 | VERTICAL | PILOT HOLE | 7990 | 7990 | HUNTSMAN SHALE |
| 49021208897100 | SNEESBY 44-9H | 41.10090757 | -104.313561 | 41.1089562 | -104.316926 | FIDELITY EXPLORATION & PRODUCTION CO | 2/18/2012 | HORIZONTAL | DRY & ABANDONED | 10193 | 7319 | NIOBRARA B |
| 49021214870000 | CARPENTER 523-0428H | 41.0419554 | -104.4439748 | 41.071073 | -104.444764 | EOG RESOURCES INC | 8/10/2019 | HORIZONTAL | OIL PRODUCER | 18002 | 7680 | NIOBRARA - FORT HAYS MEMBER |
| 49021217480000 | CARPENTER 126-0408H | 41.04195357 | -104.4437938 | 41.0170764 | -104.450751 | EOG RESOURCES INC | 8/2/2019 | HORIZONTAL | OIL PRODUCER | 17034 | 7561 | NIOBRARA B |
| 49021217490000 | CARPENTER 127-0429H | 41.041956 | -104.444156 | 41.0710773 | -104.447476 | EOG RESOURCES INC | 2/27/2019 | HORIZONTAL | OIL PRODUCER | 17757 | 7608 | NIOBRARA C |
| 49021217497000 | CARPENTER 127-0429H | 41.041956 | -104.444156 | 41.0430476 | -104.448402 | EOG RESOURCES INC | 2/16/2019 | DIRECTIONAL | PILOT HOLE | 8867 | 8684 | DAKOTA |
| 49021252260000 | ROCK PICK 1 | 41.09957547 | -104.3801916 | N/A | N/A | ANADARKO E & P ONSHORE LLC | 10/8/2017 | VERTICAL | DRY & ABANDONED | 7844 | 7844 | GREENHORN |
| (DI) 49021600140000<br>(OGC) 49021202420000<br>(IHS) 49021053100000 | ALLEN STATE 1-30 | 41.065497 | -104.12808 | N/A | N/A | ATLANTIC OIL CO | 6/25/1981 | VERTICAL | D&A-OG | 7588 | 7588 | DAKOTA GRP - SKULL CREEK SHALE |

Lily Barkau <lily.barkau@wyo.gov>

# RE: EXTERNAL: Water Well information

1 message

**Larson, Katy** <katy.larson@tallgrass.com> Mon, Jul 15, 2024 at 8:49 PM
To: "Barkau, Lily" <lily.barkau@wyo.gov>
Cc: "Harris, Tyler" <tyler.harris@wyo.gov>

Hi Lily,

I believe we used the SEO but may have made some assumptions on active wells vs. all wells.

For allocating water wells to plumes, see the associated maps. We used the same AOR assumption that was used for notice.

Please let me know if you need anything else.

**ALL Active Water Wells**

- **Azalea**: 262 water wells
  - Deepest TD of 574' bgs
- **Barberry**: 419 water wells
  - Deepest TD of 983' bgs
- **Cypress**: 253 water wells
  - Deepest has TD of 600' bgs
- **Old Barberry:** 70 water wells
  - Deepest has TD of 130' bgs
- **Spirea:** 154 water wells
  - Deepest has TD of 540' bgs

**Active Wells (NO Wells w/ Water Rights Status of Cancelled, Expired, Abandoned)**

- **Azalea:** 207 water wells
  - Deepest has TD of 574' bgs
- **Barberry**: 293 water wells
  - Deepest has TD of 910' bgs
- **Cypress:** 197 water wells
  - Deepest has TD of 600' bgs
- **Old Barberry:** 62 water wells
  - Deepest has TD of 130' bgs
- **Spirea**: 120 water wells
  - Deepest has TD of 540' bgs

**Katy Larson** | Geoscience Compliance Manager | Tallgrass Energy

T: 661.383.0879 | M: 661.203.0850

katy.larson@tallgrass.com




---

**From:** Lily Barkau <lily.barkau@wyo.gov>
**Sent:** Monday, July 15, 2024 5:16 PM
**To:** Larson, Katy <katy.larson@tallgrass.com>
**Cc:** Harris, Tyler <tyler.harris@wyo.gov>
**Subject:** Re: EXTERNAL: Water Well information

**EXTERNAL:** This email originated from an external source. Only open attachments or click on links if you are expecting them. Report any suspicious emails using Phish Alert on your email toolbar.

We typically use the SEO database. What database do you use?

On Mon, Jul 15, 2024, 5:11 PM Larson, Katy <katy.larson@tallgrass.com> wrote:

> Hi Lily,
>
> We are working on this request. What database are you using to look at the water wells? We have an inconsistency in the number of water wells.
>
> Katy
>
> ---
>
> **From:** Lily Barkau <lily.barkau@wyo.gov>
> **Sent:** Monday, July 15, 2024 3:16 PM
> **To:** Larson, Katy <katy.larson@tallgrass.com>
> **Cc:** Harris, Tyler <tyler.harris@wyo.gov>
> **Subject:** EXTERNAL: Water Well information
>
> **EXTERNAL:** This email originated from an external source. Only open attachments or click on links if you are expecting them. Report any suspicious emails using Phish Alert on your email toolbar.
>
> Hi Katy,

I have the following to complete for each permit:

There are eighty-six (86) groundwater wells within the AoR. The lowest depth of the aquifer recorded in these wells is 460 feet bgs. There are eighty-six (86) groundwater wells within the AoR. The lowest depth of the aquifer recorded in these wells is 460 feet bgs.

I have a total of 597 in the AOR but with Spirea separate, any chance you have water well numbers per plume?

Lily

Lily R. Barkau, P.G.

Groundwater Section Manager

Water Quality Division

200 W. 17th St. 2nd Floor, Cheyenne, WY 82002

Phone: 307-777-7072 | Fax: 307-635-1784

lily.barkau@wyo.gov

**NOTE:** WDEQ/WQD is going paperless! Please submit documents electronically to the WDEQ/WQD Groundwater Section through this link: **Water Quality Division Document Uploads**

If you need a large file upload link for documents greater than 30 MB, please email **deq-ims-wqd@wyo.gov**

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

**2 attachments**

**AOR_WY_All Active_Water_Well_Map_Individual Plumes_20240715.pdf**
7842K

**AOR_WY_Subset_Active_Water_Well_Map_Individual Plumes_20240715.pdf**
7842K

AoR Plus 1 Mile Radius

AoR - End of Monitoring

Active Water Well (All)
Count: 1,158

Individual Plume

## Project Wells

Proposed Injection Well

Proposed Monitoring Well

Monitoring Well

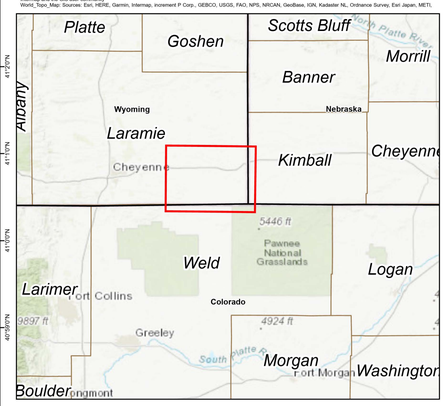
US State Boundary

PLSS Townships

PLSS Sections

*Water Wells/Springs outside the "AOR - End of Monitoring" are not shown
*Source: Water Wells/Springs - https://seo.wyo.gov/ground-water

Service Layer Credits: Reference_World_Transportation: Esri, HERE, Garmin, (c) OpenStreetMap contributors, Elevation_World_Hillshade: Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NOEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, World_Topo_Map: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI,




Produced by:

TALLGRASS
Leading Energy Solutions

Author: JMF
Date: 7/15/2024
Document Name: Petrel ArcPro Help for Subsurface Team
Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
Projection: Transverse Mercator
Datum: North American 1983

N

0 2 4 8 Miles

0 6,000 12,000 24,000 Feet

1:60,000

# Area of Review - Active Water Well Map

**Tallgrass High Plains Carbon Storage, LLC**
**Laramie County, WY**

AoR Plus 1 Mile Radius

AoR - End of Monitoring

Active Water Well - (no WRS = Cncld, Abdn, Exp) Count: 879

Individual Plume

## Project Wells

Proposed Injection Well

Proposed Monitoring Well

Monitoring Well

US State Boundary

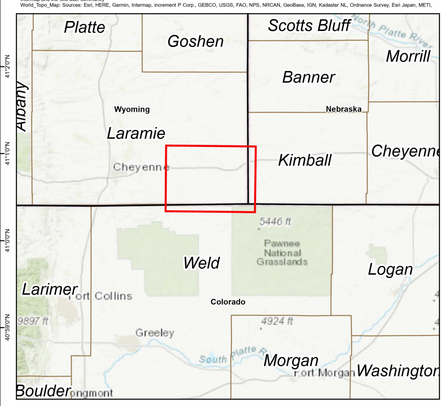
PLSS Townships

PLSS Sections

*Water Wells/Springs outside the "AOR - End of Monitoring" are not shown

*Source: Water Wells/Springs - https://seo.wyo.gov/ground-water

Service Layer Credits: Reference_World_Transportation: Esri, HERE, Garmin, (c) OpenStreetMap contributors, Elevation_World_Hillshade: Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NOEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, World_Topo_Map: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI,




# Area of Review - Active Water Well Map Subset

**Tallgrass High Plains Carbon Storage, LLC**
**Laramie County, WY**

Produced by:

TALLGRASS
Leading Energy Solutions

Author: JMF
Date: 7/15/2024
Document Name: Petrel ArcPro Help for Subsurface Team
Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
Projection: Transverse Mercator
Datum: North American 1983

N

0 2 4 8 Miles

0 6,000 12,000 24,000 Feet

1:60,000

Lily Barkau <lily.barkau@wyo.gov>

# High Plains Well Locations

1 message

**Feutz, Pete** <pete.feutz@tallgrass.com> Wed, Jul 17, 2024 at 7:35 PM
To: "Barkau, Lily" <lily.barkau@wyo.gov>, "Harris, Tyler" <tyler.harris@wyo.gov>, "Larson, Katy" <katy.larson@tallgrass.com>

Good Evening Lily,

Attached are locations for each of the five wells. All I-1 locations should match what is seen on the submitted Form 1's with one exception. We noticed a discrepancy with the Spirea I-1 Lat/Long. I have attached a revised version of the Spirea I-1 Form 1 that includes the corrected Lat/Long and have uploaded the same updated Form 1's in the Sharepoint (links below). Apologies for the confusion.

Form 1_Spirea I-1 Class VI Application_updated 7.17.24.pdf
Form 1_Spirea I-1 Class VI Application_updated 7.17.24.pdf

Would you be willing to share the Lyons thickness values that you have calculated for each well? I was not able to screen capture all of them and want to make sure we have the same values.

Thank you again for all your continued hard work on this!

Pete

**Pete Feutz** | Sr Compliance Geologist | Tallgrass Energy

T: 616.706.8011

pete.feutz@tallgrass.com

TALLGRASS
Leading Energy Solutions

**2 attachments**

**High Plains Carbon Storage_5-well Location Sheet.pdf**
65K

**Form 1_Spirea I-1 Class VI Application_updated 7.17.24.pdf**
802K

DocuSign Envelope ID: 9C1C0D5D-046E-4544-A9B0-1B8C2FBB5F6C



# GEOLOGIC SEQUESTRATION

# PERMIT APPLICATION (Form 1)

## GENERAL INFORMATION AND SIGNATORY AUTHORITY

The geologic sequestration permit application consists of two parts: (1) General Information and Signatory Authority and (2) Technical Information. All sections are to be completed in order to obtain the permit to construct. Operation of a Class VI well is not authorized until authorization to inject is received from the Department. During the construction of the Class VI well, information collected may warrant a permit modification. Only sections pertaining to the modification are required to be completed and public notice requirements will only pertain to those sections being modified. **A pre-application meeting is required prior to this application being submitted.**

**Application Type**

| | | |
|---|---|---|
| UIC Class I Conversion | ☐ | UIC Class I Permit Number: |
| UIC Class II Conversion | ☐ | Hearing Number Recommending Transfer: |
| UIC Class V Conversion | ☐ | UIC Class V Permit Number: |
| New UIC Class VI | ☑ | |
| *UIC Class VI Modification | ☐ | UIC Class VI Permit Number: 2023-041 |

*For Class VI permit modifications, only the sections requiring a modification should be completed. Permit modifications require the signature of the responsible corporate officer as well as the licensed geologist, or licensed engineer, if applicable.

**Public Notice**

In accordance with W.S. 35-11-313(f)(ii)(N), the applicant shall provide notice of the application for the geologic sequestration project proposed. Proof of notice is required to surface owners, mineral claimants, mineral owners, lessees, and other owners of record of subsurface interests that are located within one (1) mile of the proposed boundary of the geologic sequestration site. The publishing of notice of the application is required in a newspaper of general circulation in each county of the proposed operation at weekly intervals for four (4) consecutive weeks. **An affidavit of the notice shall be submitted to WDEQ. Publishing of the notice may not occur more than 14 days following the submission of the permit application.**

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**Wyoming Conservation Executive Orders 2019-3 and 2020-1**

**a. Sage Grouse**

Pursuant to the requirements of the Governor's Executive Order 2019-3 (SGEO), applicants for new UIC permits must determine if any part of the project falls within a Greater Sage-Grouse Core Area (SGCA) before applying. If any part of the project falls within an SGCA, the first point of contact for addressing sage-grouse issues is the Wyoming Game and Fish Department (WGFD). Please coordinate with the WGFD and obtain written confirmation of consistency with the Executive Order prior to applying for a UIC permit and submit this documentation as part of the application package. For more information, contact the Wyoming Game and Fish: Wyoming Game and Fish Department Habitat Protection Program (307) 777-4506 or wgfd.hpp@wyo.gov.
Note that the application shall be returned without processing until a letter confirming consistency with the Executive Order has been obtained. Additional information and maps of SGCAs are available at https://wgfd.wyo.gov/Habitat/Sage-Grouse-Management.

Check one of the following, as applicable to the project:

☐ Some part, or all, of my project falls within an SGCA and I have contacted the WGFD for a SGEO review. A letter from the WGFD confirming consistency with the Executive Order is attached.

☐ Some part, or all, of my project falls within an SGCA and I have contacted the WGFD for a SGEO review. It does not comply with the SGEO. I have valid and existing rights related to this permit. I have committed to the following recommendations that will minimize the impact on the sage grouse.

☑ By checking this box, I certify that I have reviewed the SGCAs available online, and determined that no portion of my project falls within an SGCA. *(No additional requirements apply.)*

**b. Migration Corridors.**

Pursuant to the requirements of the Governor's Executive Order 2020-1, applicants for new UIC permits must determine if any part of the project falls within a Migration Corridor designated under the Executive Order before applying. If any part of the project falls within a Migration Corridor, you must consult with the WGFD. Please coordinate with the WGFD and obtain written confirmation of consistency with the Executive Order prior to applying for a UIC permit and submit this documentation as part of the application package. For more information, contact the Wyoming Game and Fish: Wyoming Game and Fish Department Habitat Protection Program (307) 777-4506 or wgfd.hpp@wyo.gov.
Note that the application shall be returned without processing until a letter confirming consistency with the Executive Order has been obtained. Please also visit the WGFD's Management Page for more information and a map of the currently designated Migration Corridors: https://sites.google.com/view/wywildlifemigrationadvisorygrp/home?fbclid=IwAR3y_HEQxOo4HckAVKzRzT5kdLaOsyiV0vt9NJOtzNu45b_WK0vESwTWVzY#h.bc90kvcpohnu.

Check one of the following, as applicable to the project:

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☐ Some part, or all, of my project falls within the area described and I have contacted the WGFD for consultation. A letter from the WGFD confirming consistency with the Executive Order is attached.

☑ By checking this box, I certify that I have reviewed the Migration Corridors information available online, and determined that no portion of my project falls within a Migration Corridor. *(No additional requirements apply.)*

**1. General Information**

| | | | |
|---|---|---|---|
| Carbon Sequestration Project Name: Eastern Wyoming Sequestration Hub | | | |
| Owner/Operator Name Trailblazer High Plains Carbon Storage, LLC | | | |
| Responsible Corporate Officer Kyle Quackenbush | | Title Segment President & Vice President-Liquids (Crude Oil & CO2) | |
| Telephone Number 303-763-3319 | Email Address kyle.quackenbush@tallgrass.com | | |
| Owner/Operator Address 4200 West 115th Street | City Leawood | State KS | Zip 66211 |

| | | | |
|---|---|---|---|
| Facility Location Address (if different than Operator Address) | City | State | Zip |
| Telephone Number NAD 1983 Lat: 41.052367 Long: -104.424469 SWNW Sec 34 T13N R63W | | | |
| Facility Mailing Address (if different than Operator Address) | City | State | Zip |
| Telephone Number | | | |

| | | | |
|---|---|---|---|
| Consultant Name Numeric Solutions, LLC | Primary Contact Name Eric White | | |
| Consultant Address 1536 Eastman Ave Ste D | City Ventura | State CA | Zip 93003 |
| Telephone Number 805-794-5011 | Email Address eric.white@numericsolutions.com | | |
| May they be contacted directly? ☐ Yes ☑ No | | | |

DocuSign Envelope ID: 9C1C0D5D-046E-4544-A9B0-1B8C2FBB5F6C

**2. Site and Facility Description**

A description of the proposed geologic sequestration facility and documentation sufficient to demonstrate that the applicant has all legal rights, including but not limited to the right to surface use, necessary to sequester carbon dioxide and associated constituents into the proposed geologic sequestration site.

| |
|---|
| The proposed Eastern Wyoming Sequestration Hub (EWS Hub) will be located in the southeastern corner of Wyoming, in Laramie County, Section 8, Township 13N, Range 62W. Additional documentation will be provided as available. |

**3. SIC Codes**

| | | |
|---|---|---|
| List in descending order of significance the four (4) digit "Standard Industrial Classification Manual" which best describes your facility in terms of the principal products or services you produce or provide. Also, specify each classification in words. | 1st | Code/Name 4619 - Pipelines, not elsewhere classified |
| | 2nd | Code/Name 4953 - Refuse systems (Nonhazardous water disposal sites) |
| | 3rd | Code/Name |
| | 4th | Code/Name |

**4. Water Quality Management Plan, Wellhead Protection Area, Source Water Protection Area**

| | | |
|---|---|---|
| Is the Geologic Sequestration Project within a state-approved water quality management plan area? | YES ☐ | NO ☑ |
| Is the Geologic Sequestration Project within a state-approved wellhead protection area? | YES ☐ | NO ☑ |
| Is the Geologic Sequestration Project within a state-approved source water protection area? | YES ☐ | NO ☑ |

**5. Mineral and Surface Ownership for Area of Review**

| | | | | | | |
|---|---|---|---|---|---|---|
| Mineral Ownership: | ☐ | Applicant | ☐ | Surface Owner | ☐ | State |
| | ☐ | Fed | Mineral Lease # See technical report | | | |

| | | | | |
|---|---|---|---|---|
| Surface Ownership: | ☐ Applicant | ☐ State | ☐ Fed | ☐ Indian Lands (Contact EPA Region 8) |
| | ☑ Private (Specify) Lease | | | ☐ Other (Specify)_____ |

| |
|---|
| Is the facility located on any historic or archeological site? Yes ☐ No ☑ |

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## 6. Contact Information

The owner or operator shall provide a list of contacts for Tribes on Indian lands within the geologic sequestration project as defined by the Area of Review.

Attach a legal description of land ownership within the Area of Review. List ownership by tract or submit in plat form.

## 7. Access for Inspections

Wyoming Statute (W.S.) 35-11-303 (a) states: "the administrator of the water quality division at the direction of the director: (i) may conduct on-site compliance inspections of all facilities and work during or following the completion of any construction, installation or modification for which a permit is issued under W.S. 35-11-301 (a)(ii)."

As part of its application, the applicant shall certify under penalty of perjury that the applicant has secured and shall maintain permission for WDEQ personnel to access the permitted facility, including (i) permission to access the land where the facility is located, (ii) permission to collect resource data as defined by W.S. § 6-3-414, and (iii) permission to enter and cross all properties necessary to access the facility if the facility cannot be directly accessed from a public road. A map of the access route(s) to the facility shall accompany the application.

> *I,* Kyle Quackenbush *, certify under penalty of perjury that the applicant has secured and shall maintain permission for WDEQ personnel and their invitees to access the permitted facility, including (i) permission to access the land where the facility is located, (ii) permission to collect resource data as defined by Wyoming Statute § 6-3-414, and (iii) permission to enter and cross all properties necessary to access the facility if the facility cannot be directly accessed from a public road.*

## 8. Comments

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**9. Certification**

All applications for permits, reports, or information submitted to the Administrator shall be signed by a responsible corporate officer.

| | | |
|---|---|---|
| "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of a fine and imprisonment for knowing violations." | | |
| Signature DocuSigned by: Kyle Quackenbush 95601045D45742D... | Printed Name Kyle Quackenbush | |
| Title Segment President and VP - Liquids (Crude Oil and CO2) | | Date 12/21/2023 |

**10. Carbon Dioxide Stream Exclusion**

The definition of the "carbon dioxide stream" means carbon dioxide, plus associated substances derived from the source materials and any processing, and any substances added to the stream to enable or improve the injection process. Within Chapter 24, the term "carbon dioxide stream" does not include any carbon dioxide stream that meets the definition of a hazardous waste under 40 CFR 261.3. Any Class VI UIC well owner or operator, who claims that a carbon dioxide stream is excluded under paragraph (h) of 40 CFR 261.4 must have an authorized representative (as defined in WWQR Chapter 24 Section 2(mm)) sign a certification statement worded as follows:

| | | |
|---|---|---|
| "I certify under penalty of law that the carbon dioxide stream that I am claiming to be excluded under 40 CR 261.4(h) has not been mixed with, or otherwise co-injected with, hazardous waste at the UIC Class VI permitted facility, and that injection of the carbon dioxide stream is in compliance with the applicable requirements for UIC Class VI wells, including the applicable requirements in WWQR Chapter 24." | | |
| Signature DocuSigned by: Kyle Quackenbush 95601045D45742D... | Printed Name Kyle Quackenbush | |
| Title Segment President and VP - Liquids (Crude Oil and CO2) | | Date 12/21/2023 |

DocuSign Envelope ID: 9C1C0D5D-046E-4544-A9B0-1B8C2FBB5F6C



# GEOLOGIC SEQUESTRATION

## PERMIT APPLICATION

## TECHNICAL INFORMATION

The geologic sequestration permit application consists of two parts: General Information and Signatory Authority and Technical Information. Operation of a Class VI well is not authorized until authorization to inject is received from the department. During the construction of the Class VI well, information collected may warrant a permit modification. Modifications will only require sections pertaining to the modification to be completed and public notice requirements will only pertain to those sections being modified.

**To expedite the review of the permit application, an application report template is provided.** The following Table of Contents and text identifies the various sections with accompanying figures, tables, and appendices to accompany the application. All sections should be completed. If a section is not applicable, please state such in the document.

If data is not available but will be collected during well construction activities, please incorporate work plans describing the work to be completed where the text indicates as-builts or collected data. After the information is collected during well construction activities, those sections of the permit application may be revised as part of the permit modification to include as-builts and data collected. Additional figures and tables may be incorporated into the document and renamed to reflect site-specific information.

A Word document is provided to assist with completing the document. The italicized text should be deleted and replaced with site-specific information. If you have additional questions or need further clarification, please contact Lily Barkau at (307) 777-7072 or lily.barkau@wyo.gov or Graeme Finley at (307) 473-3478 or graeme.finley@wyo.gov.

| | |
|---|---|
| **Facility Name** | Eastern Wyoming Sequestration Hub, Barberry I-1 |
| **Facility Address** | T14N R61W Section 31 NW1/4 SW1/4 |
| **Well Location (NAD83)** | 41.1357081, -104.2513312 (Barberry I-1) |
| **Monitoring Well Location (NAD83)** | 41.1357009, -104.2504237 (Barberry M-1 as proposed) |

| | |
|---|---|
| **Facility Name** | Eastern Wyoming Sequestration Hub, Azalea I-1 |
| **Facility Address** | T13N R62W Section 8 SE1/4 SE1/4 |
| **Well Location (NAD83)** | 41.1012663, -104.3342721 (Azalea I-1) |
| **Monitoring Well Location (NAD83)** | 41.1012578, -104.3333651 (Azalea M-1 as proposed) |

| | |
|---|---|
| **Facility Name** | Eastern Wyoming Sequestration Hub, Spirea I-1 |
| **Facility Address** | T13N R63W Section 34 SW1/4 NW1/4 |
| **Well Location (NAD83)** | 41.052367, -104.424469 (Spirea I-1) |
| **Monitoring Well Location (NAD83)** | 41.0510846, -104.4255280 (Spirea M-1 as proposed) |

| | |
|---|---|
| **Facility Name** | Eastern Wyoming Sequestration Hub, Cypress I-1 |
| **Facility Address** | T13N R61W Section 16 SW1/4 SW1/4 |
| **Well Location (NAD83)** | 41.0864906, -104.2146252 (Cypress I-1) |
| **Monitoring Well Location (NAD83)** | 41.0864861, -104.2137183 (Cypress M-1 as proposed) |

| | |
|---|---|
| **Facility Name** | Eastern Wyoming Sequestration Hub, Old Barberry I-1 |
| **Facility Address** | T14N R61W Section 12 NW1/4 NE1/4 |
| **Well Location (NAD83)** | 41.200677, -104.144977 (Old Barberry I-1) |
| **Monitoring Well Location (NAD83)** | 41.200623, -104.144074 (Old Barberry M-1 as proposed) |

Lily Barkau <lily.barkau@wyo.gov>

# RE: EXTERNAL: Re: High Plains Well Locations

1 message

**Larson, Katy** <katy.larson@tallgrass.com> Thu, Jul 18, 2024 at 3:50 PM
To: "Barkau, Lily" <lily.barkau@wyo.gov>, "Feutz, Pete" <pete.feutz@tallgrass.com>
Cc: "Harris, Tyler" <tyler.harris@wyo.gov>

Lily,

Attached is correspondence on the location clarification for Table 1.1. The Lyons Thickness is also included in the attachment.

Please let me know if you need anything further.

**Katy Larson** | Geoscience Compliance Manager | Tallgrass Energy

T: 661.383.0879 | M: 661.203.0850

katy.larson@tallgrass.com

TALLGRASS
Leading Energy Solutions

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**From:** Lily Barkau <lily.barkau@wyo.gov>
**Sent:** Wednesday, July 17, 2024 8:46 PM
**To:** Feutz, Pete <pete.feutz@tallgrass.com>
**Cc:** Harris, Tyler <tyler.harris@wyo.gov>; Larson, Katy <katy.larson@tallgrass.com>
**Subject:** EXTERNAL: Re: High Plains Well Locations

**EXTERNAL:** This email originated from an external source. Only open attachments or click on links if you are expecting them. Report any suspicious emails using Phish Alert on your email toolbar.

If you could submit a revised Table 1.1, that would be best. The information is helpful but the original Table 1.1 is not correct and therefore I don't have a clean way to reference the information. If like to be able to reference "revised Table 1.1 as identified in supplemental information submitted July 17, 2024 (Attachment A-4)."

I am out of the office Thursday.  If you can provide the thickness for the Lyons that you have,  we'll compare to ours.

Lily

On Wed, Jul 17, 2024, 7:35 PM Feutz, Pete <pete.feutz@tallgrass.com> wrote:

> Good Evening Lily,
>
> Attached are locations for each of the five wells. All I-1 locations should match what is seen on the submitted Form 1's with one exception. We noticed a discrepancy with the Spirea I-1 Lat/Long. I have attached a revised version of the Spirea I-1 Form 1 that includes the corrected Lat/Long and have uploaded the same updated Form 1's in the Sharepoint (links below). Apologies for the confusion.
>
> Form 1_Spirea I-1 Class VI Application_updated 7.17.24.pdf
>
> Form 1_Spirea I-1 Class VI Application_updated 7.17.24.pdf
>
> Would you be willing to share the Lyons thickness values that you have calculated for each well? I was not able to screen capture all of them and want to make sure we have the same values.
>
> Thank you again for all your continued hard work on this!
>
> Pete
>
> **Pete Feutz** | Sr Compliance Geologist | Tallgrass Energy
>
> T: 616.706.8011
>
> pete.feutz@tallgrass.com

E-Mail to and from me, in connection with the transaction of public business, is subject to the Wyoming Public Records Act and may be disclosed to third parties.

**High Plains Draft Permits_Location Clarification 7.18.24.pdf**
250K

18 July 2024

**VIA E-MAIL**

Wyoming Department of Environmental Quality
c/o Lily Barkau
200 West 17th Street
Cheyenne, Wyoming 82002
Lily.Barkau@wyo.gov
cc: Tyler.Harris@wyo.gov

*Submitted via email to Lily Barkau and Tyler Harris*
*Permits: 2023-039, 2023-264, 2023-041, 2023-263, 2023-040*

Dear Ms. Barkau:

High Plains is providing clarifications to the well locations for the Old Barberry I-1 & M-1, Cypress I-1 & M-1, Azalea I-1 & M-1, Spirea I-1 & M-1, and Barberry I-1 & M-1. Table 1.1 is provided with the location information. Also provided is a table containing Lyons injection zone thickness per well location.

Old Barberry I-1 Application:

| Well Name | County | Latitude* | Longitude* | Section | Township | Range | Qrt-Qrt |
|---|---|---|---|---|---|---|---|
| Proposed Injection Well Location | | | | | | | |
| Old Barberry I-1 | Laramie | 41.200677 | -104.144977 | 12 | T14N | R61W | NW1/4 NE1/4 |
| Proposed Monitoring Well Location | | | | | | | |
| Old Barberry M-1 | Laramie | 41.200623 | -104.144074 | 12 | T14N | R61W | NW1/4 NE1/4 |

*NAD 83

Cypress I-1 Application:

| Well Name | County | Latitude* | Longitude* | Section | Township | Range | Qrt-Qrt |
|---|---|---|---|---|---|---|---|
| Proposed Injection Well Location | | | | | | | |
| Cypress I-1 | Laramie | 41.0864906 | -104.2146252 | 16 | T13N | R61W | SW1/4 SW1/4 |
| Proposed Monitoring Well Location | | | | | | | |
| Cypress M-1 | Laramie | 41.0864861 | -104.2137183 | 16 | T13N | R61W | SW1/4 SW1/4 |

*NAD 83

Azalea I-1 Application:

| Well Name | County | Latitude* | Longitude* | Section | Township | Range | Qrt-Qrt |
|---|---|---|---|---|---|---|---|
| Proposed Injection Well Location | | | | | | | |
| Azalea I-1 | Laramie | 41.1012663 | -104.3342721 | 8 | T13N | R62W | SE1/4 SE1/4 |
| Proposed Monitoring Well Location | | | | | | | |
| Azalea M-1 | Laramie | 41.1012578 | -104.3333651 | 8 | T13N | R62W | SE1/4 SE1/4 |

*NAD 83

Spirea I-1 Application:

| Well Name | County | Latitude* | Longitude* | Section | Township | Range | Qrt-Qrt |
|---|---|---|---|---|---|---|---|
| Proposed Injection Well Location | | | | | | | |
| Spirea I-1 | Laramie | 41.052367 | -104.424469 | 34 | T13N | R63W | SW1/4 NW1/4 |
| Proposed Monitoring Well Location | | | | | | | |
| Spirea M-1 | Laramie | 41.0510846 | -104.425528 | 34 | T13N | R63W | SW1/4 NW1/4 |

*NAD 83

Barberry I-1 Application:

| Well Name | County | Latitude* | Longitude* | Section | Township | Range | Qrt-Qrt |
|---|---|---|---|---|---|---|---|
| Proposed Injection Well Location | | | | | | | |
| Barberry I-1 | Laramie | 41.1357081 | -104.2513312 | 31 | T14N | R61W | NW1/4 SW1/4 |
| Proposed Monitoring Well Location | | | | | | | |
| Barberry M-1 | Laramie | 41.1357009 | -104.2504237 | 31 | T14N | R61W | NW1/4 SW1/4 |

*NAD 83

Lyons Injection Zone Thickness:

| Injection Well | Injection Zone Depths (ft) | Lyons Thickness (ft) |
|---|---|---|
| Azalea I-1 | 9,349–9,410 | 61 |
| Barberry I-1 | 9,064–9,120 | 56 |
| Spirea I-1 | 9,447–9,511 | 64 |
| Old Barberry I-1 | 8,616-8,688 | 72 |
| Cypress I-1 | 8,951–9,010 | 59 |

Kind Regards,

Katy Larson
Geoscience Compliance Manager
Tallgrass Energy Partners, LP

| √ | REQUIRED ITEM | LOCATION IN APPLICATION | COMMENT | COMMENT ADDRESSED? | FINAL REVIEW |
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| **GENERAL INFORMATION** | | | | | |
| X | Application Type (Conversion, Modification, New) | Page 1, #1 | New | | |
| X | A brief description of the nature of the business and the activities to be conducted that require the applicant to obtain a permit under this Chapter; (Chapter 24, Section 10(b)(i)) | Page 4, #2 | "The proposed Eastern Wyoming Sequestration Hub (EWS Hub) will be located in the southeastern corner of Wyoming, in Laramie County, Section 34, Township 13N, Range 63W. Additional documentation will be provided as available." Later sections of the application detail the exact location and amount of $CO_2$ to be injected. | | |
| X | The name, address, and telephone number of the operator, and the operator's ownership status and status as a federal, state, private, public, or other entity; (Chapter 24, Section 10(b)(ii)) | Page 3, #1 | All contact information provided. Limited Liability Corporation, privately owned company. | | |
| X | Up to four Standard Industrial Classification codes that best reflect the principal products or services provided by the facility; (Chapter 24, Section 10(b)(iii)) | Page 4, #3 | 4953 – Refuse systems (Nonhazardous water disposal sites) 4619 – Pipelines, not elsewhere classified | | |
| | The name, address, and telephone number of the facility; (Chapter 24, Section 10(b)(iv)) | Page 3, #1, | Not provided. In the absence of a physical address, please provide latitude and longitudinal coordinates and PLSS description. **Specific Comment No. 1.** In accordance with Wyoming Water Quality Rules (WWQR), Chapter 24, Section 10 (b)(iv), please provide a completed Permit Application Form 1, Section 1, General Information, specifying the Facility Location Address. A proposed PLSS location and latitude and longitude may be used in the absence of an actual street address. | Tallgrass May 9, 2024 Response to WDEQ's Comments. | |
| X | Whether the facility is located on Indian lands. (Chapter 24, Section 10(b)(v)) | Page 4, #5 Table 3.3 (p. 135) | Not located on Indian lands. | | |
| X | The location of the geologic sequestration project is identified by section, township, range, and county, noting which sections (if any) include Indian lands; (Chapter 24, Section 10(b)(v)) | Table 1.1 (p. 35) Figure 1.1 (p. 35) | Spirea I-1 Location: SWNW Section 34 T13N R63W, Laramie Co., 41.052367° -104.424469° Figure 1.1 Shows the entire project area. No part of the project area is on Indian lands. | | |
| X | Within the area of review, a listing and status of all permits or construction approvals associated with the geologic sequestration project received or applied for under any of the following programs or corresponding state programs: RCRA, UIC, NPDES, PSD, Nonattainment program under CAA, National Emissions Standards for Hazardous Air Pollutants pre-construction approval under CAA, Dredge and fill permitting program under CWA, other relevant environmental permits, including State permits (Chapter 24, Section 10(b)(vi)(A-G)) | Table 3.1 (p. 133) Table 3.2 (p. 134) | No other environmental permits are currently associated with this permit. Other permits that are deemed necessary as the project progresses, will be acquired. (Table 3.2). | | |
| X | Within the area of review, a list of other relevant permits associated with the geologic sequestration project that the applicant is required to obtain; (Chapter 24, Section 10(b)(vii)) | Table 3.1 (p. 133) Table 3.2 (p. 134) | Other permits that are deemed necessary as the project progresses, will be acquired. (Table 3.2). 5 other Class VI wells are associated with the project – 2023-235 (Juniper), 2023-040 (Cypress), 2023-041 (Spirea), 2023-263 (Old Barberry), 2023- | | |

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| | | | 039 (Barberry), including one to four monitoring wells associated with each permit (one deep, upper confining unit MW and up to 3 shallow aquifer MW). | | |
| X | A statement of whether the geologic sequestration project is within a state-approved water quality management plan area, a state-approved wellhead protection area or a state-approved source water protection area; (Chapter 24, Section 10(b)(viii)) | Page 4, #4<br>Figure 3.6 (p. 138) | | | |
| X | Pursuant to Wyoming Water Quality Rules (WWQR), Chapter 8, Section 6(c)(ii), the discharge of waste will not degrade or decrease the availability of mineral resources, including oil and gas. Therefore, prior to submitting an application to construct a UIC Class VI injection well, the WDEQ strongly encourages applicants to collaborate with nearby leases and mineral ownership owners to demonstrate that the proposed injection activities will present no damage to existing or future recovery of sub-surface minerals. Any permit challenge that is upheld by the WOGCC is grounds for the WDEQ to deny the issuance of the Class VI UIC permit. | Section 2.2.2.1 (pp. 63-64) | There is no known hydrocarbon production from formations below the Muddy J, approximately 1,175' above the Lyons within the project area. | | |
| | A map showing the injection well(s) for which a permit is sought and the applicable area of review, consistent with Section 13 of this Chapter;<br>• Within the area of review, the map shall list the number, or name and location of:<br>• All injection wells, producing wells, abandoned wells, plugged wells, dry holes, or deep stratigraphic boreholes;<br>• All state- or EPA-approved subsurface cleanup sites;<br>• All water quality management plan areas, wellhead protection areas, and source water protection areas;<br>• All surface bodies of water, springs, mines (surface and subsurface), quarries, and water wells;<br>• Other pertinent surface features, including structures intended for human occupancy;<br>• Roads; and<br>• State and Indian reservation boundaries;<br>(Chapter 24, Section 10(b)(ix)) | Figure 1.1 (p. 35)<br>Figure 3.4 (p. 136)<br>Figure 3.5 (p. 137)<br>Figure 3.6 (p. 138)<br>Table 3.4 (pp. 139-142) | Springs and water wells shown on Figure 3.4. All injection, producing, plugged, abandoned, dry holes displayed on Figure 3.5. Source water and wellhead protection areas shown on Figure 3.6. Table 3.4 lists all oil and gas wells in the AoR. State boundary is shown on all map figures. No Indian lands are present in the AoR.<br><br>Surface bodies of water and human occupied structures are not denoted on maps. Roads are present on satellite imagery but need to be highlighted<br><br>**Specific Comment No. 2.** In accordance with WWQR, Chapter 24, Section 10(b)(vi)(ix), please provide maps of the following or a statement that such entities do not exist within the AoR:<br><br>a. All state or EPA-approved cleanup sites<br>b. All surface bodies of water<br>c. Other pertinent surface features, including structures intended for human occupancy; | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 3 for the other four applications. | |
| X | Wyoming Conservation Executive Orders 2019-3 (Sage Grouse) and 2020-1 (Migration Corridor) | Page 2, Sections a and b | No portion of the project falls within SGCAs or Migration Corridors. | | |

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| X | Published notice of the application in a newspaper of general circulation in each county of the proposed operation is required. Published for four consecutive weeks and copy of the notice mailed to all surface owners, mineral claimants, mineral owners, lessees, and other owners of record of subsurface interest that are located within one mile of the proposed boundary of the geologic sequestration site. (W.S. 35-11-313(f)(ii)(N)) | | Affidavit of publishing received. | 12/27/23 – Affidavit of Mailing List | |
| X | A list of contacts for states or Tribes on Indian lands or territories (Chapter 24, Section 10(b)(xxxvi)) | Page 5, #6; Page 4, #5 | No part of the project on Indian lands. | | |
| X | Sections of permit applications that represent engineering work shall be sealed, signed, and dated by a licensed professional engineer as required by W.S. § 33-29-601. (Chapter 24, Section 10(e)) | Page 10 | Stamped by Ray Clanton, PE #17641. | | |
| X | Sections of permit applications that represent geologic work shall be sealed, signed, and dated by a licensed professional geologist as required by W.S. § 33-41-115. (Chapter 24, Section 10(f)) | Page 9 | Stamped by Eric White, PG #4303. | | |
| X | All applications for permits, reports, or information submitted to the Administrator shall be signed by a responsible corporate officer. (Chapter 24, Section 10(c)) | Page 6, #9 | Signed by Kyle Quackenbush, Segment President and VP – Liquids (Crude Oil and CO2), Tallgrass. | | |
| X | The application shall contain the following certification by the responsible corporate officer signing the application:<br><br>"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations." (Chapter 24, Section 10(d)) | Page 6, #9 | Signed by Kyle Quackenbush, Segment President and VP – Liquids (Crude Oil and CO2), Tallgrass. | | |
| **GEOLOGIC NARRATIVE/SITE CHARACTERIZATION INFORMATION** | | | | | |
| *The permit application will likely include a narrative description of the geologic structures, injection and confining zones, and fluid and solid geochemistry to meet the requirements of Chapter 24. The geologic narrative may be supported by maps, cross sections, and tabular data.* | | | | | |
| | **Regional Geologic Structure and Hydrogeologic Properties**<br>*The description of the geologic structure and hydrogeologic properties of the proposed storage site and overlying formations must include the items below:* | | | | |
| | **Maps and Cross Sections of the AoR**<br>*The maps and cross sections may be accompanied by a brief narrative description interpreting the figures and providing an overview of key features important to the project.*<br>• Meets the requirements of Section 13 of this Chapter;<br>• Is based upon modeling; | Appendix B<br>Sections 3.1.1-3.1.2 (pp. 128-132)<br>Section 3.4 (p. 158) | CMG GEM model: "The data sources used to construct the static geocellular model include well logs, 2D seismic data, and elements drawn from available literature."<br><br>Multiple figures have the AOR displayed. | | |

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| | • Uses all available data, including data available from any logging and testing of wells within and adjacent to (within one (1) mile of) the area of review; and<br>• Describes the area of review by township, range, and section to the nearest ten (10) acres, as described under the general land survey system;<br>*(Chapter 24, Section 10(b)(x))* | | Applicant proceeded to use the EERC's risk-based AoR approach but did not offer the results of modelling (i.e. EPA approach) that would have indicated that approach was appropriate.<br><br>**Specific Comment No. 13.** Section 3.1.2 *Supporting Maps* of the permit application states "As discussed in Appendix B, the extent of the pressure front at the critical pressure threshold is smaller than the $CO_2$ plume extent, therefore the AoR is determined by the $CO_2$ plume extent."<br><br>a. Please clarify how you arrived at this conclusion incorporating evaluations of the AoR (using the EPA approach) that indicate a different methodology (i.e. the risk-based approach) is appropriate. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 14 for the other four applications. | |
| | **<u>Demonstration of Site Suitability</u>**<br>*This narrative demonstration may be accompanied by maps, cross sections, tables or relevant geological data, or descriptions of model inputs/results. It must describe:*<br>• The suitability of the injection zone (An injection zone of sufficient areal extent, thickness, porosity, and permeability to receive the total anticipated volume of the carbon dioxide stream (Chapter 24, Section 12 (a)(i)), and<br>• The suitability of the confining zone (Confining zones that are free of transmissive faults or fractures and of sufficient areal extent and integrity to contain the injected carbon dioxide stream and displaced formation fluids and allow injection at proposed maximum pressures and volumes without initiating or propagating fractures in the confining zones or causing non-transmissive faults to become transmissive. *(Chapter 24, Section 12(a)(ii))*<br>*(*) It may also describe additional confining zone(s); a description of additional confining zones is not required of all projects.*<br>• Isopach maps of the proposed injection and confining zones, a structural contour map aligned with the top of the proposed injection zone, and at least two (2) geologic cross-sections of the area of review reasonably perpendicular to each other and showing the geologic formations from the surface to total depth; *(Chapter 24, Section 10(b)(xi)(A))* | Section 1.6 (p. 37)<br>Located throughout Section 2 (pp. 39-127) | Section 1.6 details the criteria used to determine site suitability. Geologic narrative, Cross sections, Structure and Isopach maps for UCZ, Injection Zone and LCZ provided.<br><br>All depths associated with the UCZ, Injection Zone and LCZ are reported in SSTVD with no well elevation reported. Please provide measured depth values for all depths reported in the permit application.<br><br>Upper Confining:<br>Chugwater, MD, Goose<br>Egg, MD Injection Zone:<br>Lyons, MD<br>Lower Confining: Satanka, MD | **Specific Comment No. 22:** Please provide measured depth values for all depths reported in the permit application. This data can be submitted as a table that includes the measured and subsea depths of all formations whose depths were reported only as subsea in the permit application, including the depths and ranges of depths given on pages 67, 70, 94, 96, 103 and 104 of the permit application and | Tallgrass July 5, 2024 Response to WDEQ's Comments. |

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| | | | | pages B-14 and B-17 of Appendix B | |
| X | **Information on Faults and Fractures**<br>*This may be a narrative description of the location, orientation, and properties of known or suspected faults and fractures and a discussion supporting a determination that they would not interfere with containment. It may be accompanied by maps and cross sections and be supported by analyses of core samples, the results of geophysical surveys, pore pressure data, etc.*<br>• Location, orientation, and properties of known or suspected faults and fractures that may transect the confining zones in the area of review and a determination that they will not allow fluid movement;<br>• Information on seismic history that has affected the proposed area of review including knowledge of previous seismic events and history of these events, the presence and depth of seismic sources, and a determination that the seismicity will not allow fluid movement out of the injection zone;<br>*(Chapter 24, Section 10(b)(xi)(B-C))* | Figure 2.17 (p. 74)<br>Section 2.4.3 (pp.118-120) | Figure 2.17 shows the 2D seismic lines used to determine there are no faults in the AoR.<br><br>2.4.3.1 states "The upper confining zone if free of transmissive faults or fractures within the AoR."<br><br>2.4.3.1 also mentions Tallgrass ran SLB oil-based ultrasonic borehole image tool and interpreted open fractures to be drilling induced. Dipole sonic was used to look for open fractures further from the wellbore. There is no discussion of the interpretation of the dipole sonic. | **Specific Comment No. 23:** Please submit a discussion of how the dipole sonic tool was used to determine that open fractures are not transmissive, including a description of the depth of investigation of the dipole sonic tool. | Tallgrass July 5, 2024 Response to WDEQ's Comments. |
| X | **Data on the Injection Zone(s)**<br>*This narrative may describe plans to collect or the results of geologic cores, outcrop data, seismic surveys, well logs, lithologic descriptions, and other field data used to characterize the injection zone(s), including geology/facies changes. The application must address the following types of data on the injection zone(s):*<br>• Data sufficient to demonstrate the effectiveness of the injection and confining zones, including:<br>o Data on the depth, areal extent, thickness, mineralogy, porosity, vertical permeability, and capillary pressure of the injection and confining zones within the area of review; and<br>o A description of geologic changes based on field data that may include geologic cores, outcrop data, seismic surveys, well logs, and names and lithologic descriptions;<br>*(Chapter 24, Section 10(b)(xi)(D))* | Throughout Section 2.4 (pp. 75-124) | Data from the Juniper M-1 strat test:<br>Table 2.22 (p. 99) Lyons: Depth: 9,128'-9,194'; Avg. 67' thick; Sandstone, predominantly quartz with <2% clay and no calcite.<br>Table 2.7 (p. 80) Porosity: 15.7% (core); Perm: 501 mD (core)<br>Section 2.4 focuses on the geological characteristics of the injection zone. Data presented includes core and log data as well as mineralogy. Preliminary geomechanical information indicates a fracture gradient of 0.57 psi/ft and will be updated with future data. Data presented includes core analysis, XRD data, water sampling, cross sections and maps of the Lyons, well logs (Juniper M-1 and others). | | |
| X | **Data on the Confining Zone(s)**<br>*This narrative may describe plans to collect or the results of geologic cores, outcrop data, seismic surveys, well logs, lithologic descriptions, and other field data used to characterize the confining zone(s), including geology/facies changes. The application must address the following types of data on the confining zone(s):*<br>• Data sufficient to demonstrate the effectiveness of the injection and confining zones, including: | Section 2.4.2 including all subsections (pp. 99-118) | Section 2.4.2 including all subsections covers the geology of the UCZ and LCZ. Core, log and geochemical data are provided, as are maps and cross sections. The permeability of the UCZ and LCZ are in the 0.001mD range with 5% avg phi, indicating good sealing rocks are present. The UCZ and LCZ are both predominantly shale and are sufficiently thick (Satanka 189', Chugwater/Goose Egg ~500'). | | |

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| | ○ Data on the depth, areal extent, thickness, mineralogy, porosity, vertical permeability, and capillary pressure of the injection and confining zones within the area of review; and<br>○ A description of geologic changes based on field data that may include geologic cores, outcrop data, seismic surveys, well logs, and names and lithologic descriptions;<br>*(Chapter 24, Section 10(b)(xi)(D))* | | | | |
| | **Geomechanical and Petrophysical Information about the Confining Zone(s)**<br>*A narrative description of the confining zone(s) may describe the testing performed (or planned) and available results in a tabular and/or graphical form; it may include maps and present seismic or other geophysical data, core data, or well logs. The application must address the following about the confining zone(s): (Chapter 24, Section 10(b)(xi)(E))* | Section 2.4.2.1.3 (p. 109)<br>Table 2.25 (p. 110)<br>Section 2.4.2.2.3 (pp. 118-120)<br>Section 2.4.2.2.4 (p. 117)<br>Table 2.28 (p. 117) | Elastic properties available for UCZ and LCZ (some properties pending analysis) are present. | | |
| X | Fractures. | Section 2.4.3.1 (pp. 116-119) | The upper confining zone is free of transmissive faults or fractures within the AoR.<br><br>**Specific Comment No. 3.** In accordance with WWQR, Chapter 24, Section 10(b)(xi)(E), please provide the following geomechanical data:<br><br>a. Stress<br>b. Rock Strength<br>c. In situ fluid pressures<br><br>If this geomechanical data has not yet been collected, please provide a full, stepwise procedure for how this data will be collected for WDEQ review and approval. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 4 for the other four applications. | |
| | Stress. | Table 2.25 (p. 110)<br>Table 2.28 (p. 117) | TBD<br>**Specific Comment No. 3.** | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 4 for the other four applications. | |
| X | Ductility. | Table 2.25 (p. 108)<br>Table 2.28 (p. 115) | Young's modulus for Goose Egg 25.6-55.1.<br>Young's modulus for Satanka 34.6-35.2.<br>**Specific Comment No. 3.** | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment | |

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| | | | | No. 4 for the other four applications. | |
| | Rock strength. | Table 2.25 (p. 110)<br>Table 2.28 (p. 117) | TBD<br>**Specific Comment No. 3.** | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 4 for the other four applications. | |
| | In situ fluid pressures. | | Missing<br>**Specific Comment No. 3.** | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 4 for the other four applications. | |
| X | **Information on Seismic History**<br>*A narrative description of the presence and depth of seismic sources and a determination that seismicity would not interfere with containment that may be accompanied by tables and/or maps of seismic events, sources, and depths. (Chapter 24, Section 10(b)(xi)(C))* | Section 2.4.3.2 (p. 121-124) | "The probabilistic acceleration map, shown in Figure 2.42, illustrates that the EWS Hub is located in one of the lowest-risk areas of Wyoming." | | |
| | **Geologic and Topographic Maps and Cross Sections**<br>*These maps and cross sections of regional geology, hydrogeology, and local geologic structure may be accompanied by a narrative description or interpretations of logs or core data. (Chapter 24, Section 10(b)(xi)(F))* | Throughout Sections 2 & 3 | Myriad maps and cross sections included in Sections 2 & 3. | | |
| | **Hydrologic Information/Maps and Cross Sections of USDWs**<br>*The maps and stratigraphic cross sections of the vertical and lateral limits of all USDWs may be accompanied by a narrative interpretation of the figures. The maps/cross sections must show: (Chapter 24, Section 10(b)(xiv))* | | | | |
| X | Water wells and springs within the AoR. | Figure 3.4 (p. 136) | Embedded map is small scale and difficult to read, however, Tallgrass included a standalone high resolution image in the Figures and Tables folder. | Located in Original Application Material, Figures and Tables folder. | |
| X | Their positions relative to the injection zone(s). | Figure 2.2 (p, 41)<br>Figure 2.7 (p. 47)<br>Figure 2.8 (p. 48) | Shown in stratigraphic column; Figure 2.2<br>Shown on cross section; Figure 2.7, Figure 2.8 | | |
| X | The direction of water movement, where known. | Section 2.2.2 (p. 61)<br>Figure 2.14 (p. 63)<br>Figure 2.20 (p. 78) | Groundwater recharges in the mountains on the western flank of the basin and travels eastward. | | |

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| | **Baseline Geochemical Data**<br>*The narrative description of available geochemical data on fluid- and solid-phase geochemistry of all subsurface formations (including USDWs) in the AoR may describe: results or planned sampling/testing, the parameters analyzed, and any geochemical modeling that was performed, along with data sources, data quality or gaps, and sampling/testing methods. It may be accompanied by tabular or graphical data, statistics, and maps. (Chapter 24, Section 10(b)(xvi))* | Section 4.4.3 #2 (p. 213) | "High Plains has no plans to collect fluid samples from subsequent monitoring wells and will instead collect fluid samples from relevant formations in all injection wells within the EWS Hub."<br><br>Chapter 24 requires water samples from injection zone and lowermost USDW.<br>Only geochemical data for the Lyons is presented.<br><br>**Specific Comment No. 18.** Section 2.3.6 *Fluid Samples* of the permit application states "Based on the narrative of the well operations prior to and during sampling, it is not reasonable or possible to claim that water samples obtained are truly from and representative of the Lyons Formation." Section 2.3.6 (PDF page 69) goes on to state "A review of the daily drilling and completion reports shows there is a possibility that the Lyons Formation water sample collected could be contaminated from brine present in the wellbore at the time of sampling. High Plains will collect additional fluid samples in the Lyons Formation in the Azalea I-1 prior to injection."<br><br>a. Tallgrass will also need to collect water samples from the Sundance Formation, Hygiene Sandstone Member of the Pierre Shale, and the following shallow USDWs:<br><br>i. Quaternary alluvial and terrace deposits<br>ii. "High Plains Regional Aquifer System" or "Tertiary Aquifer System"<br>iii. Ogallala, Arikaree, and White River formations<br>iv. Lance and Fox Hills formations | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 19 for the other four applications. | |
| | **Groundwater Classification**<br>*For the characterization required by W.S. 35-11-313(f)(ii)(B), information necessary for the Division to classify the receiver and any secondarily affected aquifers under Water Quality Rules and Regulations Chapter 8; (Chapter 24, Section 10(b)(xv))* | Section 2.2.1 (pp. 49-58)<br>Section 2.3.6 (pp. 69-71)<br>Appendix C | DEQ has questions on sampling procedure. Permit application also express doubts in water sample quality (Section 2.3.6, pp. 70-71). Will require new sample taken in Spirea I-1 via a sampling methodology approved by WDEQ.<br><br>Lyons TDS ~224,000ppm.<br><br>**Specific Comment No. 19.** Per Specific Comment 19, Tallgrass shall submit their water sampling plan(s) to the WDEQ for | Tallgrass May 9, 2024 Response to WDEQ's | |

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| | | | review and approval prior to collecting any samples, to ensure such samples will be satisfactory to the WDEQ. | Comments. NOTE: This comment is Specific Comment No. 20 for the other four applications. | |
| **WELL CONSTRUCTION** | | | | | |
| X | **CO2 Compatibility**<br>*The compatibility of the carbon dioxide stream with fluids in the injection zone and minerals in both the injection and the confining zones, based on the results of the formation testing program, and with the materials used to construct the well; (Chapter 24, Section 10(b)(xviii))* | Section 2.4.1.8 (pp. 95-99)<br>Section 4.3.2 (p. 193) | Section 2.4.1 Covers formation compatibility.<br>Section 4.3.2 states "To meet the requirements of WYDEQ Chapter 24 §20(b)(iii), High Plains will conduct corrosion monitoring of the well's tubing, casing, and pipeline materials using a corrosion coupon monitoring system." Please provide documentation that all well construction materials meet the various API codes listed in Chapter 24 Section 14.<br><br>**Specific Comment No. 7.** In accordance with WWQR, Chapter 24, Section 10(b)(xxxiii), the well plugging plan requires the type, grade, and quantity of material to be used in well plugging to be submitted. Additionally, please provide information on how these materials meet or exceed the American Petroleum Institute standards per WWQR Chapter 24, Section 14(b)(i). | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 8 for the other four applications. | |
| X | **Formation Testing Program**<br>*Proposed formation testing program to obtain an analysis of the chemical and physical characteristics of the injection zone and confining zone and that meets the requirements of Section 17 of this Chapter; (Chapter 24, Section 10(b)(xix))* | Section 4.3 (pp.188-192)<br>Table 4.21: I-1 logging program (p.207)<br>Table 4.26: M-1 logging program (p. 212) | Please provide summaries of formation testing done in the Juniper and planned for the Spirea I-1 and M-1.<br>Table 4.21 is the Spirea I-1 proposed logging program. Table 4.26 is the Spirea M-1 proposed logging program.<br><br>**Specific Comment No. 4.** In accordance with WWQR, Chapter 24, Section 10(b)(xix), please provide procedures for the formation testing programs to be done in the Spirea I-1 and M-1. | Not Addressed. Additional information is needed in regard to shallow wells, including swab sampling procedures for wells not utilizing MDT. Additionally, please provide a demonstration that using the MDT minifrac tool to | Tallgrass July 5, 2024 Response to WDEQ's Comments. |

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| | | | | determine fracture gradient to establish LSIP is comparable to an injectivity or pump test, such as an SRT. NOTE: This comment is Specific Comment No. 5 for the other four applications. | |
| | **Stimulation Program**<br>*Proposed stimulation program, a description of stimulation fluids to be used, and a determination that stimulation will not allow fluid movement out of the injection zone; (Chapter 24, Section 10(b)(xx))* | Section 5 (pp. 237-240)<br>Appendix J | Section 5 states "A stimulation program will be executed upon WYDEQ approval." Appendix J contains an example of a mud acid workover. It is labelled Proposed Stimulation Plan, but appears incomplete.<br>Proposed plans are acceptable for now, but a detailed workover plan needs to be approved prior to well construction.<br><br>**Specific Comment No. 5.** In accordance with WWQR, Chapter 24, Section 10(b)(xx), a detailed stimulation plan will need to be submitted for WDEQ's review and approval prior to issuance of authorization to inject under a modified permit. If the stimulation is to be done under the Permit to Construct as part of formation testing, this plan needs to be submitted with a response to these comments for WDEQ's review and approval prior to issuance of the Permit to Construct. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 6 for the other four applications. | |
| X | **Schematics**<br>*A wellbore schematic of the subsurface construction details and surface wellhead construction of the injection and monitoring wells; (Chapter 24, Section 10(b)(xxii))* | Figure 4.3 (p. 195)<br>Figure 4.5 (p. 202)<br>Figure 4.6 (p. 209) | Proposed well design for three groundwater monitoring wells.<br>Spirea I-1<br>Spirea M-1 | | |
| X | **Design and Construction**<br>*Injection well design and construction procedures that meet the requirements of Section 14 of Chapter 24, including the information listed in Section 14(c)(ii) of Chapter 24; (Chapter 24, Section 10(b)(xxiv))* | Figure 4.3 (p. 196)<br>Table 4.18 (p.205)<br>Table 4.19 (p.205)<br>Table 4.20 (p. 206) | Tables and wellbore diagrams provide most of the required information. See note regarding API standards in **Well Construction > CO2 Compatibility** in this checklist.<br><br>**Specific Comment No. 16.** Section 4.4.2 *Proposed Monitoring Well Casing and Cementing Programs* of the permit application states "The well will be drilled through the Sundance and will penetrate the top of the Chugwater," whereas Section 4.5.2.1 *Pre-plugging Procedures 2. Determination of bottomhole reservoir pressure* states "The well is not expected to be perforated or open to any formation and the total depth at drilling and completion was to be above the containment layers for the Lyons | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 17 for the other four applications. | |

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| | | | sequestration reservoir."<br><br>a. These statements both refer to the monitoring wells and contradict each other. Please clarify if the Chugwater or Goose Egg will be penetrated by the monitoring well(s).<br>b. Monitor wells cannot penetrate the upper confining zone as drilling operations may compromise the integrity of the confining zone. | Note: Based on the response, monitoring well(s) cannot be drilled until permit modification occurs due to the need to collect data during the injection well drilling. | |
| | **Logging, Sampling and Testing Prior to Injection Well Operations**<br>*All available logging and testing program data on the wells required by Section 17 (Chapter 24, Section 10(b)(xxvii))* | Section 4.3 (pp.188-201) Table 4.21: I-1 logging program (p.207)<br>Table 4.26: M-1 logging program (p. 212) | Please provide summaries of formation testing done in the Juniper M-1 and planned for the Spirea I-1 and M-1.<br>Table 4.21 is the Spirea I-1 proposed logging program. Logging program looks good. Table 4.26 is the Spirea M-1 proposed logging program. Logging program looks good.<br><br>**Specific Comment No. 4.** In accordance with WWQR, Chapter 24, Section 10(b)(xix), please provide procedures for the formation testing programs to be done in the Spirea I-1 and M-1. | Not Addressed. Additional information is needed in regard to shallow wells, including swab sampling procedures for wells not utilizing MDT. Additionally, please provide a demonstration that using the MDT minifrac tool to determine fracture gradient to establish LSIP is comparable to an injectivity or pump test, such as an SRT. NOTE: This comment is Specific Comment No. 5 for the other four applications. | Tallgrass July 5, 2024 Response to WDEQ's Comments. |

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| **PLANNED WELL OPERATIONS** | | | | | |
| X | **Proposed Operations**<br>*Proposed procedure that outlines steps to conduct injection operations; (Chapter 24, Section 10(b)(xxi)* | Section 5.0 (pp. 237-240) | Includes SRT procedures. | | |
| X | **Proposed average and maximum daily rate and volume and/or mass and total anticipated volume and/or mass of the CO2 stream.**<br>*A narrative or tabular description that may be accompanied by calculations. (Chapter 24, Section 10(b)(xvii)(A))* | Table 5.1 (p. 237) | 10.62 million metric tons total over 30 years<br>1,656 metric tons/day average<br>4,101 metric tons/day maximum | | |
| X | **Proposed average and maximum injection pressure.**<br>*A narrative or tabular description that may be accompanied by calculations. (Chapter 24, Section 10(b)(xvii)(B))* | Table 5.1 (pg. 237) | 1,597 psi Maximum Surface Injection Pressure<br>1,420 psi Average Surface Operating Injection Pressure<br>1,520 psi Proposed Tubing-Casing Annulus Pressure | | |
| X | **The source(s) of the CO2.**<br>*A narrative description of the CO2 source. (Chapter 24, Section 10(b)(xvii)(C))* | Section 5.0 (pp. 237-238)<br>Table 5.2 (p. 238) | The $CO_2$ to be injected will be sourced from ethanol plants, ammonia plants, and power plants then transported on the Trailblazer pipeline to the Spirea I-1. | | |
| X | **An analysis of the chemical and physical characteristics of the CO2 stream.**<br>A narrative description that may be accompanied by tables of parameters or analytical reports. *(Chapter 24, Section 10(b)(xvii)(D))* | Table 5.2 (p.238) | >95 mol% CO2 | | |
| X | **Duration**<br>*Anticipated duration of the proposed injection period. (Chapter 24, Section 10(b)(xvii)(E))* | Section 5 (p. 237) | 5-30 years depending on injection rate (up to maximum of 10.62 million metric tons total injection) | | |
| **AREA OF REVIEW (AoR) AND CORRECTIVE ACTION PLAN** | | | | | |
| | *Proposed area of review and corrective action plan that meets the requirements under Section 13 of Chapter 24 (Chapter 24, Section 10(b)(xxv))* | | | | |
| | **The Method for Delineating the AoR.**<br>*A narrative description of the AoR delineation model used, which may include assumptions made, any available outputs/results, and the inputs on which the model is based. It may be accompanied by tables, figures and graphics, or raw data in a tabular format. (Chapter 24, Section 13)* | Section 3.1.1 (p.128) | "The AoR is defined as "the subsurface three-dimensional extent of the carbon dioxide plume, associated pressure front, and displaced fluids, as well as the overlying formations, and surface area above that delineated region" [Ch. 24 §2(c)], the lateral extent of the AoR herein includes any area where the modeled CO2 saturation exceeds 2% at plume stabilization, or where threshold pressure is exceeded in the injection zone at any time during the modeled timeframe."<br><br>The AoR was calculated using the risk-based method, however, the EPA method should have been done first to determine if an alternate method was necessary. Please calculated the AoR using the EPA method and explain why it is or isn't an appropriate method for determining the AoR.<br><br>**Specific Comment No. 13.** Section 3.1.2 *Supporting Maps* of the permit application states "As discussed in Appendix B, the extent of the pressure front at the critical pressure threshold is smaller than the $CO_2$ plume extent, therefore the AoR is | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: | |

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| | | | determined by the $CO_2$ plume extent."<br><br>a. Please clarify how you arrived at this conclusion incorporating evaluations of the AoR (using the EPA approach) that indicate a different methodology (i.e. the risk- based approach) is appropriate | This comment is Specific Comment No. 14 for the other four applications. | |
| X | **AoR Reevaluation Schedule and Criteria, Including:**<br>• *A description of the minimum fixed frequency, not to exceed 5 years, for AoR reevaluations.*<br>• *The monitoring and operational conditions that would warrant a reevaluation of the AoR prior to the next scheduled reevaluation; and*<br>• *How monitoring and operational data will be sued to inform an AoR reevaluation. (Chapter 24, Section 13)* | Section 3.5 (p. 168)<br>Section 3.6 (p. 173) | "High Plains will regularly reevaluate the AoR and corrective action plan, per the requirements of WYDEQ Chapter 24 §13(c), at least every two years during the operational life of the EWS Hub and every five years during the post-injection site care period (until site closure)—or when monitoring and operational conditions warrant a reevaluation prior to the next scheduled reevaluation." | | |
| | **Corrective Action Information**<br>A narrative discussion of how corrective action was/will be conducted. If phased corrective action is planned, the application must describe the following: | Section 3.3 (p. 158)<br>Table 3.10 (p. 168)<br>Section 3.5 (pp. 170-171) | "A total of 654 wells (597 water wells and 57 oil and gas wells) have been identified within the AoR. Of these, only three penetrate the upper confining zone. Two wells are shown in Table 3.10, with Juniper M-1 being discussed separately." This differs from the number of wells within the AoR reported in the Barberry I-1 permit application. Please address this discrepancy.<br><br>Well remediation procedure listed on pp. 170-171.<br><br>**Specific Comment No. 6.** In accordance with WWQR, Chapter 24, Section 13(c)(i-iv), please provide a discussion of how Tallgrass will re-evaluate wells for corrective action within an adjusted AoR.<br><br>a. Section 3.5 *Area or Review and Corrective Action Plan* of the permit application states that there are 654 wells (57 oil wells) within the AoR. The Barberry I-1 permit application (Permit # 2023-039) reports 657 wells (60 oil wells) within the AoR. Please address this discrepancy and adjust Table 3.4 and Table B.6 of Appendix B accordingly.<br><br>**Specific Comment No. 14.** Section 3.6 *Reevaluation of AoR and Corrective Action Plan* of the permit application states "A report will be generated to include the data and results demonstrating that no changes are necessary. If material changes have occurred, then the conceptual model will be updated with the new data and a report will be generated and sent to WYDEQ. This report will | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 7 for the other four applications. | |

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| | | | include comparisons between the previous simulation and the updated version, details of potential corrective action and a current status of the corrective action. The report will be submitted to WDEQ within one year of the reevaluation."<br><br>a. If any change to the AoR has occurred, the conceptual model must be updated and a report generated which must be submitted with the next scheduled semiannual report. If a report that demonstrates no changes are necessary is submitted, it must also be submitted with the next scheduled semiannual report for WDEQ review and approval. Changes to the AoR and corrective action plan will require a permit modification. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 15 for the other four applications. | |
| X | How the phasing will be determined. | | No discussion of phasing corrective action. | Only required if they were planning a phased corrective action. As no phased corrective action planned, no discussion needed. | |
| | How corrective action will be adjusted if there are changes in the AoR. | | No discussion of Corrective Action changes<br>**Specific Comment No. 6.** In accordance with WWQR, Chapter 24, Section 13(c)(i-iv), please provide a discussion of how Tallgrass will re-evaluate wells for corrective action within an adjusted AoR.<br><br>a. Section 3.5 *Area or Review and Corrective Action Plan* of the permit application states that there are 654 wells (57 oil wells) within the AoR. The Barberry I-1 permit application (Permit # 2023-039) reports 657 wells (60 oil wells) within the AoR. Please address this discrepancy and adjust Table 3.4 and Table B.6 of Appendix B accordingly.<br><br>**Specific Comment No. 14.** Section 3.6 *Reevaluation of AoR and Corrective Action Plan* of the permit application states "A report will be generated to include the data and results demonstrating that no changes are necessary. If material changes have occurred, then the conceptual model will be updated with the new data and a report will be generated and sent to WYDEQ. This report will include comparisons between the previous simulation and the updated version, details of potential corrective action and a | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 7 for the other four applications.<br><br>Tallgrass May 9, 2024 Response to | |

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| | | | current status of the corrective action. The report will be submitted to WDEQ within one year of the reevaluation."<br><br>a. If any change to the AoR has occurred, the conceptual model must be updated and a report generated which must be submitted with the next scheduled semiannual report. If a report that demonstrates no changes are necessary is submitted, it must also be submitted with the next scheduled semiannual report for WDEQ review and approval. Changes to the AoR and corrective action plan will require a permit modification. | WDEQ's Comments. NOTE: This comment is Specific Comment No. 15 for the other four applications. | |
| X | How site access for future corrective action will be guaranteed. | Page 5, #7 | Site access is covered on Page 5, #7. | | |
| X | **Tabulation of Wells in the AoR**<br>The AoR and Corrective Action Plan must include a table listing wells within the AoR (within one mile) that penetrate the injection or confining zones or a statement there are no wells that penetrate the confining zone within the AoR. Other penetrations of the confining zone(s), such as underground mines, also must be identified. If a table is submitted, it must include the following information: *(Chapter 24, Section 10(b)(xii-xiii))* | Table 3.4 (pp. 139-142) Table 3.10 (p. 168) Table B.6 (pp. 310-314) Table B.7 (pp. 317-336) | Several tables tabulate wells data for wells within AOR. Table 3.4 is a condensed deep well table and Table B.6 is a more comprehensive table. Table B.7 lists water wells in the AOR, but only has columns for Permit Number, Status, Use, Facility Name and Well Depth. Table 3.10 is a complete table for wells that penetrate the confining zone within the AOR. | Original Application, Table 3.10 | |
| X | Well Type. | Table 3.10 (p. 168) | Present in table. | | |
| X | Description of the well's construction. | Table 3.10 (p. 168) | Present in table. | | |
| X | Date drilled. | Table 3.10 (p. 168) | Present in table. | | |
| X | Location. | Table 3.10 (p. 168) | Present in table. | | |
| X | Depth. | Table 3.10 (p. 168) | Present in table. | | |
| X | Record of plugging and/or completion. | Table 3.10 (p. 168) | WOGCC Completion Reports provided in Appendix A. | | |
| **TESTING AND MONITORING PLAN** | | | | | |
| | **Testing and Monitoring Plan**<br>*Proposed testing and monitoring plan required by Section 20 (Chapter 24, Section 10(b)(xxxii)). The Testing and Monitoring Plan will be a narrative description of planned injection-phase testing activities that is accompanied by maps, tables, illustrations, or step-by-step procedures that describe the following:* | Section 4.3 (pp.188-201) | See below. | | |
| X | **CO2 Stream Analysis**<br>*Narrative description that may describe analytical parameters, sampling methods, sampling locations, and frequencies.* | Section 4.3.1 (pp. 189-19) | "High Plains will collect continuous samples of the $CO_2$ injection stream and perform analysis to meet the requirements of WYDEQ Chapter 24 §20(b)(i), to obtain data representative of the injectate stream's chemical and physical characteristics." "The $CO_2$ stream samples will be continuously collected from the $CO_2$ pipeline using a gas chromatograph on the flowline before the injection flowmeter." | | |

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| X | **Continuous Recording of Operational Parameters**<br>*Narrative description of devices to continuously monitor and record injection pressure, rate, and volume; tubing-casing annulus pressure; and annulus fluid volume added. May be depicted on well schematics.* | | Various mentions of continuous monitoring through fiber optic cables in wellbore, but no specific discussion of continuous monitoring. | **Specific Comment No. 24:** Please provide additional information specific to continuous monitoring. | Tallgrass July 5, 2024 Response to WDEQ's Comments. |
| X | **Corrosion Monitoring**<br>*Narrative description of corrosion monitoring methods that may describe sampling methods/locations or testing frequency.* | Section 4.3.2 Subsection 2 (p. 193) | "The coupons will be removed quarterly and assessed for corrosion using American Society for Testing and Materials (ASTM) standards at a certified laboratory." | | |
| X | **Above Confining Zone Monitoring**<br>*Narrative description of planned water quality monitoring that may describe well locations; analytical methods and parameters; sampling locations and methods, formations/depths, and frequencies. The description may be accompanied by maps, monitoring well schematics, or tables of analytical parameters and methods.* | Table 4.11 (p. 189) | "Monitoring well with fiber optic and gauges behind casing" | | |
| X | **External Mechanical Integrity Testing**<br>*Narrative (sometimes step-by-step) description of mechanical integrity tests (MITs) and their planned frequency. (Chapter 24, Section 10(b)(xxviii))* | Section 4.3.1.1 Subsection 4 (p. 192) | "As required by WYDEQ Chapter 24 §24.19(c) and §24.20(b)(v), a fiber optic (DTS) temperature log will be recorded and archived annually to determine the absence of significant fluid movement, thus ensuring mechanical integrity. Before beginning injection operations, a temperature baseline will be established for future comparisons." | | |
| X | **Pressure Fall-Off Testing**<br>*Narrative (sometimes step-by-step) description of pressure fall-off tests and their planned frequency.* | Section 4.3.1.1 Subsection 2 (p. 191-192) | "High Plains will conduct a baseline pressure falloff test before injection and then every five years." | | |
| X | **Direct CO2 Plume and Pressure Front Tracking**<br>*Narrative description of planned direct methods to track the CO2 plume and pressure front that may include well locations; analytical methods and parameters; sampling locations and formations/depths; and frequencies. The description may be accompanied by maps, monitoring well schematics, or tables of analytical parameters and methods.* | Section 4.3.8 (pg. 196)<br>Table 4.15 (pp. 196-197)<br>Section 4.3.9 (pg. 198) | "Direct and indirect monitoring methods will be used to track the extent of the CO2 plume within the injection formation throughout the injection and post-injection monitoring periods, per the methods described in Table 4.15."<br>"The CO2 plume will be directly monitored by temperature and pressure gauges placed via TEC line as well as a fiber optics system behind the casing in both the injection well and the monitoring well." | | |
| X | **Indirect CO2 Plume and Pressure Front Tracking**<br>*Narrative description of planned indirect methods to track the Co2 plume and pressure front; it may describe: well locations; monitoring equipment; or geophysical survey extent/resolution. The description may be accompanied by maps, monitoring well or equipment schematics, or tables.* | Section 4.3.10 (pg. 198) | "The extent of the $CO_2$ plume will be monitored using time-lapse 2D seismic surveys."<br>"High Plains plans to utilize DTS in the Spirea M-1 annually to monitor all zones above the injection zone. Due to the high resolution nature of this tool, this method of monitoring will inform High Plains of any carbon dioxide or saline fluids migrating out of the injection zone." | | |
| | ***Surface Air Monitoring and/or Soil Gas Monitoring** | Section 4.3.7 (p. 195)<br>Table 4.14 (p.195) | "CO2 in air monitors will also be placed to monitor the air above the water level in each of these monitoring wells." No other air | | |

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| | *This type of monitoring is not required for all projects; if it is included, it would be a narrative description of planned methods detect CO2 in the soil or atmosphere (including monitoring locations, equipment, and frequencies) that may be accompanied by maps or illustrations.* | | monitoring will be done.<br>"High Plains has determined that a soil gas monitoring plan is not necessary to monitor potential Leakage."<br>Soil Gas Monitoring is required.<br>**Specific Comment No. 17.** Section 4.6.3 *Groundwater and Soil Gas Monitoring* of the permit application states "High Plains does not plan to monitor soil gas at this time as monitoring efforts in the first permeable layer above the confining zone and shallow groundwater sampling will identify leaks before a soil gas survey would."<br><br>a. Pursuant to WWQR Chapter 24 Section 20(b)(ix), soil gas monitoring is required. Please provide a soil gas monitoring plan. | Not addressed. Please provide clarification as to when the monitoring well(s) will be drilled. In addition, any updates to construction designs are considered a minor permit modification and therefore, modified plans are required to be submitted to WDEQ for review and approval prior to drilling.<br>Comments. NOTE: This comment is Specific Comment No. 18 for the other four applications. | Tallgrass July 5, 2024 Response to WDEQ's Comments. |
| X | ***Other Monitoring**<br>*Additional monitoring is not required for all projects; if it is included, it would be a narrative description of the types of monitoring (e.g., seismic), including methods, equipment, locations, and frequencies that may be accompanied by maps, illustrations, or tables.* | Table 4.2 (p. 177)<br>Table 4.11 (p. 188) | Seismic monitoring mentioned in Emergency and Remedial Response Plan, Table 4.2. Monitoring program is listed in Table 4.11. | | |
| X | **Quality Assurance and Surveillance Plan**<br>*Narrative description of planned quality assurance procedures for all testing and monitoring activities.* | Table 4.2 (pp. 178-179)<br>Table 4.11 (p. 188) | | | |
| **INJECTION WELL PLUGGING PLAN** | | | | | |
| | *Proposed injection and monitoring wells plugging plan required by Section 23 (Chapter 24, Section 10(b)(xxxiii))* | Section 4.5 (p. 214-219) | "This section provides an overview of plugging operations after injection operations have ceased at Spirea I-1. High Plains intends to properly plug and abandon the injection well under the requirements of WYDEQ Chapter 24 §23." | | |

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| X | **Well Plugging Plan**<br>*The Well Plugging Plan may be a narrative (sometimes step-by-step) description of plugging procedures for the injection well. It may be accompanied by schematics and tables. The plan must include the following information:* | Section 4.5 (p. 214-224)<br>Figure 4.7 (p. 219)<br>Figure 4.8 (p. 224) | Figure 4.7 – P&A Wellbore Diagram for Injector<br>Figure 4.8 – P&A Wellbore Diagram for MW | | |
| X | Tests or measures for determining bottomhole reservoir pressure. | Section 4.5 Pre-plugging procedures #2 (p. 214) | "Bottomhole pressure will be measured with a wireline gauge run through tubing. The well should be shut in for a sufficient time to ensure the reservoir pressures are stabilized." | | |
| X | External mechanical integrity testing methods. | Section 4.5 Pre-plugging procedures #3 (pp. 214-215) | "External mechanical integrity will be demonstrated through approved temperature logging methods. The following procedure is to demonstrate mechanical integrity, release packer, recover tubing, and clean out the wellbore." | | |
| X | The type and number of plugs to be used. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Table 4.27 summarizes plugs, Section 4.5.1 describes the plugs, and Figure 4.7 is the wellbore diagram for the Spirea I-1. | | |
| X | The placement of each plug, including the elevation of the top and bottom of each plug. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Figure 4.7 | | |
| X | The type, grade, and quantity of material to be used in plugging. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Table 4.27 and Figure 4.7. | | |
| X | The method of placement of the plugs. | Section 4.5.1 (pp.215-218)<br>Table 4.27 (p.218)<br>Figure 4.7 (p. 219) | Narrative in Section 4.5.1 (pp.214-217) | | |
| **POST-INJECTION SITE CARE (PISC) AND SITE CLOSURE PLAN** | | | | | |
| X | **PISC and Site Closure Plan**<br>*Proposed post-injection site care and site closure plan required by Section 24(a)(Chapter 24, Section 10(b)(xxxiv)). The plan will be a narrative discussion, accompanied by maps, cross sections, tables, or model outputs that must include the following information:* | Section 4.6 (pg. 225-236) | | | |
| X | The differential between pre-injection and predicted post-injection pressures in the injection zone(s). | Section 4.6.1 (pg. 225-233) | "The maximum injection pressure buildup is 1,391 psi." | | |
| X | The predicted position of the CO2 plume and associated pressure front at site closure. | Figure 4.14 (p.232) | Map of maximum plume extent. | | |
| X | A description of post-injection monitoring locations, methods, and proposed frequencies. *This may include well locations; analytical methods and parameters; and sampling locations, formations/depths, and frequencies.* | Section 4.6.4 (p.234) | "As indicated in Table 4.4, the $CO_2$ plume and pressure front will be monitored after injection activities cease. Reservoir temperatures and pressures will be measured in injection wells. The extent of the plume will indirectly be measured with time-lapse 2D surveys. Data gathered from these two methods during post-injection will be used to validate the predicted plume model. If data differs from the predicted behavior, the model will | | |

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| | | | be updated." | | |
| X | A proposed schedule for submitting post-injection site care monitoring results. | Section 4.6.5 (pp. 234-235)<br>Table 4.29 (p. 234) | "All data and analysis gathered during PISC monitoring activities will be submitted to WYDEQ and the EPA annually, within 60 days of the anniversary of injection cessation. The reports will contain groundwater data, storage reservoir pressures and temperature, seismic data, and any reservoir simulation results from new data." | | |
| X | The duration of the post-injection site care timeframe. | Section 4.6 (p. 225) | "To be conservative, High Plains plans to conduct post-injection monitoring for 50 years after injection ceases to confirm that the model does not show a risk of migration to the USDW or beyond the Project Site boundary." | | They modeled for 20-30 years but they will continue PISC for 50 years regardless. |
| X | The results of computational modeling of the AoR. | Figure 4.10 (p. 227)<br>Figure 4.11 (p. 228)<br>Figure 4.14 (p. 232) | Discussed in AOR section as well. | | |
| | The predicted rate of CO2 plume migration within the injection zone and the predicted timeframe for the cessation of migration. | Section 4.6.1 (pp. 229)<br>Figures 4.14 (p. 232) | "The rate of CO2 migration within the injection zone is primarily controlled by structural dip, facies, porosity and permeability distribution. A discussion of these geological properties and their adaptation and inclusion in the CO2 plume modeling is included in the application narrative. Figure 4.14 shows the pressures and CO2 plume at end of injection, through stabilization and the end of PISC."<br>No rates reported.<br><br>**Specific Comment No. 8.** In accordance with WWQR, Chapter 24, Section 24(a)(ii)(K), the predicted rate of $CO_2$ plume migration within the injection zone is required. Please update the permit application to include this information. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 9 for the other four applications. | |
| | A description of the site-specific processes that will result in CO2 trapping. | Section 4.6 (pp. 229-230) | "At the end of the modeled timeframe (model year 2105), approximately 8.18 MMT of $CO_2$ is structurally trapped. Residual trapping stores 1.80 MMT. Solubility trapping accounts for approximately 0.61 MMT of $CO_2$ at the end of the model runtime. | | |
| | The predicted rate of CO2 trapping. | Section 4.6 (pp. 229-230) | No rates reported.<br>**Specific Comment No. 9.** In accordance with WWQR, Chapter 24, Section 24(a)(ii)(M), the predicted rate of $CO_2$ trapping is required. Please update the permit application to include this information. | Not addressed. Although graphs are provided, rates are not clearly | Tallgrass July 5, 2024 Response to WDEQ's Comments. |

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| | | | | identified. Please provide a numerical value for the rate at the end of the PISC. NOTE: This comment is Specific Comment No. 10 for the other four applications. | |
| X | The results of laboratory analyses, research studies, and/or field or site-specific studies to verify the above information. | Section 2 and Section 3 | Previously discussed in monitoring section. | | |
| X | A characterization of the confining zone(s), including a demonstration that it is free of faults and fractures and is sufficiently thick, and will impede fluid movement. | Section 2.4.2 including all subsections (pp. 99-118) | Previously discussed. | | |
| X | A description of the well's construction and an assessment of the quality of plugs of all abandoned wells in the AoR. | Section 3.3 (p. 158)<br>Table 3.10 (p. 168)<br>Section 3.5 (pp. 168-173) | Previously discussed. | | |
| X | The distance between the injection zone and the nearest USDWs. | Figure 2.2 (p. 41)<br>Figure 2.7 (p. 47)<br>Figure 2.8 (p. 48) | Previously discussed. | | |
| **EMERGENCY AND REMEDIAL RESPONSE PLAN** | | | | | |
| X | Proposed emergency and remedial response plan required by Section 25 (Chapter 24, Section 10(b)(xxxv)) | Section 4.1 (pp. 175-184) | | | |
| **FINANCIAL ASSURANCE** | | | | | |
| | A demonstration, satisfactory to the Administrator, that the applicant has met the financial responsibility requirements of Section 26; (Chapter 24, Section 10(b)(xxix)) | Section 4.2 (pp. 184-188) | Monitoring and testing financial assurance is missing. **Specific Comment No. 10.** In accordance with WWQR, Chapter 24, Section 26(a)(ii), financial assurance for each phase of the project is required including monitoring and testing; financial assurance for each phase is required to be reported separately from other financial assurance estimates. | Not addressed. Please explain why the ERR Monte Carlo simulation for the Spirea returned different results than the other four wells which had results that appeared to be identical to each other. NOTE: This comment is Specific Comment No. 11 for the other four applications. | Tallgrass July 5, 2024 Response to WDEQ's Comments. |

| √ | REQUIRED ITEM | LOCATION IN APPLICATION | COMMENT | COMMENT ADDRESSED? | FINAL REVIEW |
|---|---|---|---|---|---|
| X | A written financial assurance cost estimate required by Section 26(b); (Chapter 24, Section 10(b)(xxx)) | Appendix G | Written financial assurance cost estimate provided in Appendix G. | | |
| | A public liability insurance certificate that, in addition to meeting the requirements of W.S. § 35-11-313(f)(ii)(O), demonstrates that the public liability insurance policy meets the requirements of Section 26(l)(i)(B) of this Chapter; identifies each facility by name, address, and EPA Identification Number; and identifies the amounts and types of coverage for each facility; (Chapter 24, Section 10(b)(xxxi)) | Appendix G | Certificate is blank and needs to be completed prior to permit to construct.<br><br>**Specific Comment No. 11.** In accordance with WWQR, Chapter 24, Section 10(b)(xxxi), a public liability insurance certificate that, in addition to meeting the requirements of W.S. § 35-11-313(f)(ii)(O), demonstrates that the public liability insurance policy meets the requirements of Section 26(l)(i)(B) of this Chapter; identifies each facility by name, address, and EPA Identification Number; and identifies the amounts and types of coverage for each facility is required prior issuance of a Permit to Construct. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 12 for the other four applications. | Tallgrass July 5, 2024 Response to WDEQ's Comments. |
| **GENERAL COMMENTS** | | | | | |
| | The basis for the following comments is identified below as part of the Application Completeness/Preliminary Technical Adequacy Review. A checklist for the application is attached for further reference. | | **General Comment No. 1.** The basis for the following comments is identified below as part of the Application Completeness/Preliminary Technical Adequacy Review. A checklist for the application is attached for further reference. | NA | |
| | Applicants have a maximum of six (6) months to address WDEQ's comments. If the requested information is not addressed within the six (6) month period, the permit will be denied and the incomplete application shall be returned. | | **General Comment No. 2.** Applicants have a maximum of six (6) months to address WDEQ's comments. If the requested information is not addressed within the six (6) month period, the permit will be denied and the incomplete application shall be returned. | Response to DEQ's comments received May 9, 2024. | |
| | Resubmittal of information for a deficient application will start the sixty (60) day review period again. | | **General Comment No. 3.** Resubmittal of information for a deficient application will start the sixty (60) day review period again. | Response from DEQ to be received no later than July 9, 2024. | |
| | Please ensure consistent units are used throughout the application. For example, SSTVD is reported in some situations while MD is used in others. While SSTVD is acceptable, please also report the corresponding MD. | | **General Comment No. 4.** Please ensure consistent units are used throughout the application. For example, SSTVD is reported in some situations while MD is used in others. While SSTVD is acceptable, please also report the corresponding MD. | Not addressed. See **Specific Comment No. 22** above. | Tallgrass July 5, 2024 Response to WDEQ's Comments. |
| | Please ensure to use a consistent operator name throughout the application. | | **General Comment No. 5.** Please ensure to use a consistent operator name throughout the application. | Not addressed. Please provide an updated Form 1 for each well as follows:<br>• Spirea: Correct operator name | Tallgrass July 5, 2024 Response to WDEQ's Comments. |

| √ | REQUIRED ITEM | LOCATION IN APPLICATION | COMMENT | COMMENT ADDRESSED? | FINAL REVIEW |
|---|---|---|---|---|---|
| | | | | from Trailblazer High Plains Carbon Storage LLC. to Tallgrass High Plains Carbon Storage LLC and correct the conflicting Section, Township and Range information provided in Parts 1 and 2 | |
| **ADDITIONAL COMMENTS** | | | | | |
| | Section 2.4.1.5 of the permit application states "Note oil saturation > 0 is indicative of oil-based mud invasion." Provide evidence as to how oil saturation in the core taken in the Juniper M-1 can be as high as 46% due to drilling with oil-based mud. | | **Specific Comment No. 12.** Section 2.4.1.5 of the permit application states "Note oil saturation > 0 is indicative of oil-based mud invasion." Provide evidence as to how oil saturation in the core taken in the Juniper M-1 can be as high as 46% due to drilling with oil-based mud. | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 13 for the other four applications. | |
| | Table 4.3 *Actions necessary to determine cause of events and appropriate emergency response* of the permit application states "If a seismic event occurs within the AoR of the injection well, of a magnitude greater than 3.0, review the pressure and volume injection history to determine if there is a correlation with the injection activities. Confirm that the well has maintained mechanical integrity and whether a loss of $CO_2$ containment has occurred."<br><br>The WDEQ requires quarterly reporting of all seismic events greater than 1.0. At this time, the WDEQ cannot support a minimum magnitude reporting threshold of 3.0. Final minimum magnitude reporting threshold numbers cannot be established until further data is collected from the well area. | | **Specific Comment No. 15.** Table 4.3 *Actions necessary to determine cause of events and appropriate emergency response* of the permit application states "If a seismic event occurs within the AoR of the injection well, of a magnitude greater than 3.0, review the pressure and volume injection history to determine if there is a correlation with the injection activities. Confirm that the well has maintained mechanical integrity and whether a loss of $CO_2$ containment has occurred."<br><br>a. The WDEQ requires quarterly reporting of all seismic events greater than 1.0. At this time, the WDEQ cannot support a minimum magnitude reporting threshold of 3.0. Final minimum magnitude reporting threshold numbers cannot be established until further data is collected from the well area | Tallgrass May 9, 2024 Response to WDEQ's Comments. NOTE: This comment is Specific Comment No. 16 for the other four applications. | |
| | Tallgrass shall submit final plans for water sampling, monitoring, completions, injection and monitor well plugging, internal and external mechanical integrity testing, and any other well operation | | **Specific Comment No. 20.** Tallgrass shall submit final plans for water sampling, monitoring, completions, injection and monitor well plugging, internal and external mechanical integrity testing, | Tallgrass May 9, 2024 Response to WDEQ's | |

| √ | REQUIRED ITEM | LOCATION IN APPLICATION | COMMENT | COMMENT ADDRESSED? | FINAL REVIEW |
|---|---|---|---|---|---|
| | procedures to the WDEQ for review and approval prior to performing any of these activities. | | and any other well operation procedures to the WDEQ for review and approval prior to performing any of these activities. | Comments. NOTE: This comment is Specific Comment No. 21 for the other four applications. | |
| **May 9, 2024 Tallgrass Submittal – additional Barberry I-1, Azalea I-1, Old Barberry I-1, Spirea I-1, and Cypress I-1 Permit Updates and Proposed Changes** | | | | | |
| | Page 50 of 61: Step Rate Test | Tallgrass May 9, 2024 Response to WDEQ's Comments. | | **Specific Comment No. 4** not addressed. See WDEQ's follow-up questions/comments to Tallgrass Response for missing information to WDEQ Specific Comment No. 4 NOTE: This comment is Specific Comment No. 5 for the other four applications. | Tallgrass July 5, 2024 Response to WDEQ's Comments. |
| | Page 50 of 61: Injection Well 130' Rathole Justification | Tallgrass May 9, 2024 Response to WDEQ's Comments. | | | |
| | Page 55 of 61: "This supports the conclusion that the Amazone is not considered a USDW." | Tallgrass May 9, 2024 Response to WDEQ's Comments. | Although the "Application for Class II wells-Samson Energy 2020" notes that the TDS of the Amazon is greater than 10,000 ppm, there are several locations that are below 10,000 ppm. The conclusions drawn in that report that "drilling mud" caused the decrease in concentrations, information on the drilling mud would need to be provided to confirm this claim.<br><br>Note: This does not need to be answered prior to Permit to Construct. | **Specific Comment No. 25:** TDS concentrations can be determined through sample analysis or calculation from conductivity information available. Please provide additional information to support that the Amazon is not a USDW. | Tallgrass July 5, 2024 Response to WDEQ's Comments. |

| √ | REQUIRED ITEM | LOCATION IN APPLICATION | COMMENT | COMMENT ADDRESSED? | FINAL REVIEW |
|---|---|---|---|---|---|
| | Specific Comment No. 21 | | This checklist will not have a Specific Comment No. 21 in order to align other Specific Comments 22, 23, 24, and 25 to the other four permit applications and avoid confusion in addressing comments. | No Specific Comment No. 21. | |

## ATTACHMENT A-5: Public Notice Affidavit for Draft Permit Public Notice

Public Participation, Public Notice and Public Hearing Requirements are in accordance with Water Quality Rules, Chapter 24, Section 27.

- Affidavit of Publication – Public Notice, Wyoming Tribune Eagle, Published July 31, 2024.
- Affidavit of Publication – Public Notice, Casper Star-Tribune, Published July 30, 2024.

CASPER Star Tribune

**AFFIDAVIT OF PUBLICATION**

See Proof on Next Page

Catherine Hardway
DEQ Water Quality Division
State of Pennsylvania, County of Lancaster, ss:

Hayden Lipsky, being first duly sworn, deposes and says: That (s)he is a duly authorized signatory of Column Software, PBC and duly authorized agent of Casper Star-Tribune, a division of Lee Publications, Inc. A newspaper published in CASPER， NATRONA COUNTY, WYOMING, who declares that the attached Notice was published in said newspaper on the following dates：

**PUBLICATION DATES:**
Jul. 30, 2024

**NOTICE ID:** Jr0mMVIXzoMzYFhfUNRq
**PUBLISHER ID:** COL-WY-0439
**NOTICE NAME:** Class VI Tallgrass Permits
**TOTAL AD COST:** $196.24
**FILED ON:** Jul. 24, 2024

(Signed) Hayden Lipsky

**VERIFICATION**

State of Pennsylvania
County of Lancaster

Commonwealth of Pennsylvania - Notary Seal
Nicole Burkholder, Notary Public
Lancaster County
My commission expires March 30, 2027
Commission Number 1342120

Subscribed in my presence and sworn to before me on this: 07/30/2024

Nicole Burkholder
Notary Public
Notarized remotely online using communication technology via Proof.

**Wyoming Department of Environmental Quality Notice of Proposed Underground Injection Control Permit Eastern Wyoming Sequestration Hub Tallgrass High Plains Carbon Storage LLC**

The Underground Injection Control (UIC) Class VI Program regulates the storage of carbon dioxide in underground geologic reservoirs. Operators of such facilities are required to receive coverage under a UIC permit. The permits contain limitations and conditions that will ensure underground sources of drinking water are protected. Prior to issuing Class VI permits, the UIC Program prepares a 60-day public notice to inform interested parties of proposed permits and offers an opportunity to provide written comments.

The purpose of this notification is to inform the public that the UIC Class VI Program is proposing the issuance of five (5) permits for Tallgrass High Plains Carbon Storage LLC, 4200 West 115th Street, Leawood, KS 66211 as follows:

(1) Permit # 2023-039, Barberry – NWSW Qrt of Section 31, Township 14 North, Range 61 West;

(2) Permit # 2023-040, Cypress – SWSW Qrt of Section 16, Township 13 North, Range 61 West;

(3) Permit # 2023-041, Spirea – SWNW Qrt of Section 34, Township 13 North, Range 63 West;

(4) Permit # 2023-263, Old Barberry – NWNE Qrt of Section 12, Township 14 North, Range 61 West;

(5) Permit # 2023-264, Azalea – SESE Qrt of Section 8, Township 13 North, Range 62 West.

The proposed permits are for Class VI UIC wells at a geologic sequestration site in southeast Wyoming in Laramie County. The UIC Class VI Program has prepared a public notice that is available at the WDEQ's website ( https://deq.wyoming.gov/public-notices/ under "WATER-Underground Injection Control") . The public notice includes a copy of the currently proposed permit and relevant application material. The public notice defines the process and deadline for providing written comments. Hard copies of the draft permit and attachments are available at the DEQ offices in Cheyenne, Sheridan, Casper, and Lander, and the Wyoming State and the Laramie County Libraries in Cheyenne.

The public comment period begins July 30, 2024 , and ends October 1, 2024 . The UIC Class VI Program will hold a hearing following the public comment period on October 1, 2024, at the Laramie County Library, 2000 Pioneer Avenue, Cheyenne, WY 82001 in the Cottonwood Room. An informational meeting will be held from 5:00 p.m. to 6:00 p.m. with the hearing from 6:00 p.m. to 8:00 p.m.

If you have any questions, please contact Lily R. Barkau, P.G., Wyoming Department of Environmental Quality, Water Quality Division, 200 West 17th Street, Cheyenne, WY 82002, 307-777-7072, lily.barkau@wyo.gov.

Para Español, visite deq.wyoming.gov . *Americans with Disabilities Act: Special assistance or alternative formats will be made available upon request for individuals with disabilities. Please provide at least 14 days before the close of the public comment period for such requests.*

Published: July 30, 2024
Legal No: COL-WY-0439

From:
Wyoming Tribune Eagle
702 W. Lincolnway
Cheyenne, WY 82001

**Affidavit of Publication**

Description of advertisement:
Tallgrass High Plains Carbon Storage
Published: 07/31/24
AD# 541744

THE STATE OF WYOMING ) ss.
County of Laramie )

I, Blanche McDonald, do solemnly swear that I am the Publisher's Agent of the **Wyoming Tribune Eagle,**, a newspaper of general circulation published in the **County of Laramie, State of Wyoming;**; that the notice, of which the attached is a true copy, was published in said newspaper for 1 publications, the first having been made on 07/31/2024, and the last publication having been made on 07/31/2024; that said notice was published in the regular and entire issue of said newspaper during the period and times of publication aforesaid and that the notice was published in the newspaper proper, and not in a supplement.

Publication fees: $168.33

Subscribed and sworn to before me
on this date: August 1 2024

LASHA HERNANDEZ
NOTARY PUBLIC
STATE OF WYOMING
COMMISSION ID: 163335
MY COMMISSION EXPIRES: 10/28/2029

Notary Public

**Wyoming Department of Environmental Quality Notice of Proposed Underground Injection Control Permit Eastern Wyoming Sequestration Hub Tallgrass High Plains Carbon Storage LLC**

The Underground Injection Control (UIC) Class VI Program regulates the storage of carbon dioxide in underground geologic reservoirs. Operators of such facilities are required to receive coverage under a UIC permit. The permits contain limitations and conditions that will ensure underground sources of drinking water are protected. Prior to issuing Class VI permits, the UIC Program prepares a 60-day public notice to inform interested parties of proposed permits and offers an opportunity to provide written comments.

The purpose of this notification is to inform the public that the UIC Class VI Program is proposing the issuance of five (5) permits for Tallgrass High Plains Carbon Storage LLC, 4200 West 115th Street, Leawood, KS 66211 as follows:

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(2) Permit # 2023-040, Cypress – SWSW Qrt of Section 16, Township 13 North, Range 61 West;

(3) Permit # 2023-041, Spirea – SWNW Qrt of Section 34, Township 13 North, Range 63 West;

(4) Permit # 2023-263, Old Barberry – NWNE Qrt of Section 12, Township 14 North, Range 61 West;

(5) Permit # 2023-264, Azalea – SESE Qrt of Section 8, Township 13 North, Range 62 West. The proposed permits are for Class VI UIC wells at a geologic sequestration site in southeast Wyoming in Laramie County. The UIC Class VI Program has prepared a public notice that is available at the WDEQ's website (https://deq.wyoming.gov/public-notices/ under "WATER-Underground Injection Control"). The public notice includes a copy of the currently proposed permit and relevant application material. The public notice defines the process and deadline for providing written comments. Hard copies of the draft permit and attachments are available at the DEQ offices in Cheyenne, Sheridan, Casper, and Lander, and the Wyoming State and the Laramie County Libraries in Cheyenne.

The public comment period begins July 30, 2024, and ends October 1, 2024. The UIC Class VI Program will hold a hearing following the public comment period on October 1, 2024, at the Laramie County Library, 2000 Pioneer Avenue, Cheyenne, WY 82001 in the Cottonwood Room. An informational meeting will be held from 5:00 p.m. to 6:00 p.m. with the hearing from 6:00 p.m. to 8:00 p.m.

If you have any questions, please contact:
Lily R. Barkau, P.G.,
Wyoming Department of Environmental Quality, Water Quality Division,
200 West 17th Street, Cheyenne, WY 82002, 307-777-7072,
lily.barkau@wyo.gov.

**Para Español, visite** deq.wyoming.gov.

Americans with Disabilities Act: Special assistance or alternative formats will be made available upon request for individuals with disabilities. Please provide at least 14 days before the close of the public comment period for such requests.

July 31, 2024
NO. 541744

## ATTACHMENT A-6: Public Comments and Responses

Public Participation, Public Notice and Public Hearing Requirements are in accordance with Water Quality Rules, Chapter 24, Section 27. The public comment period was held from July 30 through October 1, 2024. One commentor submitted comments:

- Mr. Conner Nicklas, Wyoming Nebraska Pore Space Owners Association

September 26, 2024

Wyoming Department of Environmentally Quality
200 West 17th St.
Cheyenne, WY 82002

Re: Support for Proposed Underground Injection Control Permit Eastern Wyoming Sequestration Hub Tallgrass High Plains Carbon Storage LLC

To Whom It May Concern,

The Wyoming Nebraska Pore Space Owners Association is writing in support of Tallgrass High Plains Carbon Storage's Eastern Wyoming Sequestration Hub and the five Class VI applications (Barberry, Cypress, Spirea, Old Barberry, and Azalea wells). Our organization represents more than 350 private landowners owning nearly 200,000 acres of land in Laramie County, WY that have entered into pore space lease and pipeline easement agreements with Tallgrass High Plains Carbon Storage.

Our association was able to successfully negotiate a robust lease agreement with Tallgrass that offers many protections for our member landowners, including liability protections, reclamation requirements, and water quality provisions. In addition to entering into a mutually beneficial lease with our members, Tallgrass has made itself available to our members, both in providing numerous open house events and other public meetings and also by making Tallgrass personnel personally available to landowners whenever they have had questions regarding the project. Because of this robust lease and the continued transparency Tallgrass has given to landowners during the leasing and permitting process, we trust Tallgrass to safely develop this new infrastructure which will sequester carbon emissions captured from industrial operations in underground geologic formations and reduce atmospheric carbon.

The Eastern Wyoming Sequestration hub will benefit many local landowners and the community as a whole by adding a new income source to many local small businesses. Furthermore, the project will potentially provide new opportunities in the future that are often the lifeblood of this local community and many of the agricultural operations that greatly benefit from these kinds of projects.

On behalf of the Wyoming Nebraska Pore Space Owners Association and the landowners we represent, we encourage your approval of the Barberry, Cypress, Spirea, Old Barberry, and Azalea Class VI permits.

Respectfully Submitted,



Wyoming Nebraska Pore Space Owners Association

October 7, 2024

Mr. Conner Nicklas
Wyoming Nebraska Pore Space Owners Association
300 E. 18th Street
Cheyenne, WY 82003

***Sent Via Email: KJensen@buddfalen.com***

RE: Draft UIC Permit: Tallgrass High Plains Carbon Storage, LLC, Class VI
Comments Received Via Smart Comment, September 27, 2024

Dear Mr. Nicklas:

The Wyoming Department of Environmental Quality Water Quality Division (WDEQ/WQD), Underground Injection Control (UIC) Program received your comment dated September 26, 2024 regarding the Tallgrass High Plains Carbon Storage, LLC, Class VI Draft Permits (Permit Nos. 2023-039, 2023-040, 2023-041, 2023-263, and 2023-264). Below is the comment received followed by our response.

**Comment:** On behalf of the Wyoming Nebraska Pore Space Owners Association and the landowners we represent, we encourage your approval of the Barberry, Cypress, Spirea, Old Barberry, and Azalea Class VI permits.

**WDEQ/WQD Response:** WDEQ/WQD thanks you for your comment. All UIC Class VI applications are reviewed for completeness and technical adequacy for WDEQ Regulations. Comments received during the public comment period will be considered as to the technical or regulatory authorities for WDEQ/WQD. A permit that meets Wyoming Regulations will be finalized for approval and issuance by the WDEQ Director.

Based on WDEQ/WQD's review of the permit application materials and comments submitted to the Department during the public comment period, no modifications to the draft permits were identified. Therefore, the Department plans to proceed with the issuance of permit nos. 2023-039, 2023-040, 2023-041, 2023-263, and 2023-264. If you have any questions or feel that a meeting is necessary to discuss this correspondence, please do not hesitate to contact me at (307) 777-7072 or lily.barkau@wyo.gov.

Sincerely,

Lily R. Barkau, P.G.
Groundwater Section Manager
Water Quality Division
Wyoming Department of Environmental Quality

cc: Tyler Harris, P.G., Hunter Hubbard, P.G., file WDEQ/WQD
Kyle Quackenbush, Tallgrass High Plains Carbon Storage, LLC (kyle.quackenbush@tallgrass.com)

## ATTACHMENT A-7: Public Hearing Transcript

Public Participation, Public Notice and Public Hearing Requirements are in accordance with Water Quality Rules, Chapter 24, Section 27. A Public Hearing was held on October 1, 2024. No official comments were received at the public hearing.

**WYOMING UNDERGROUND INJECTION CONTROL PROGRAM**

**CLASS VI PERMIT HEARING**

**APPLICATIONS 2023-039, 2023-040, 2023-041, 2023-263, and 2023-264**

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**TRANSCRIPT OF MEETING PROCEEDINGS**

**Lily Barkau**

So, good evening. This is the Tallgrass High Plains Carbon Storage, Eastern Wyoming Sequestration Hub for five Class VI permits. Tonight's public meeting was broken into two parts, an informational meeting, which was held from 5:00 to 6:00 PM, and now a hearing to receive any comments for the draft permits that are in public notice, which will end tonight at 8:00 PM. Let the record show this hearing is being convened at 6:00 PM Tuesday, October 1st, 2024 at the Laramie County Library, Cottonwood and Sage rooms located at 2000 Pioneer Ave. Cheyenne, WY 82001.

We have convened this meeting today as an additional opportunity to receive comments on the DEQ's advertised proposal to issue five Underground Injection Control Class VI permits to construct to Tallgrass High Plains Carbon Storage for geologic sequestration injection activities in Laramie County.

We will now open the meeting for comments. As a reminder, this meeting is not a contested case hearing. People offering statements today will not be subject to cross-examination or be questioned by the audience. We will not engage in open discussion or rebuttal of issues raised by the participant. I or anyone on this panel may request additional information or ask questions of any participant if needed to clarify these statements. We do ask that you come to the front here so that the recorder can clearly gather your information and comments. Please provide your name and the spelling of your name, and if you are here for a company, organization, or media, I ask that you provide that information as well. Are there any commenters this evening?

Not seeing any comments for this evening. Thank you all for attending and this concludes the hearing. We will be available for any general questions that you may have available, but the hearing is now closed at 6:02. Thank you.